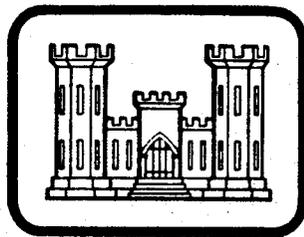


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20 JAN 1981

# **SOUTHEASTERN NEW HAMPSHIRE**

## **WATER RESOURCES STUDY**

### **STAGE 2 DOCUMENTATION**



**DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.**

**JANUARY 1981**

## EXECUTIVE SUMMARY

The Southeastern New Hampshire area has a chronic water shortage problem which results from circumstances beyond the control of the individual communities. Growth in the area has been extremely rapid, spurred on by the area's close proximity to the Greater Boston Metropolitan area. Improved roads and very low taxes have prompted many of out state residents to move into the area. The resulting general economic boom has brought enormous increases in population and business to the area thus spiraling the demand for water.

Communities in the study area developed, as did most New England communities, with an autonomic town government system. When it became necessary to go from private wells to public systems, the communities took over the responsibility of providing drinking water. Most, but not all of the communities, found that the cheapest way of providing high quality water was to develop available shallow aquifer wells. These well systems were adequate for many years and as populations grew new wells were developed and put into service.

More recently however the towns have not been able to locate and develop new sources at the same pace as the demand for water has grown. In some areas new well sites are nonexistent in others aquifers are either already developed, to their maximum potential or lost to residential or commercial improvement. Some aquifers are being abandoned because of contamination. It should also be noted that groundwater availability is much higher in the northern part of the study area while populations are heaviest in the southern portion. Communities with surface water supplies are also beginning to face the problem of locating additional supplies.

This combination of circumstances, has made future water supply shortages a regional problem while solutions are presently being sought at the community level.

A resolution proposed by Congressman James C. Cleveland was passed on September 23, 1976, directing the Corps of Engineers to examine the whole water resource situation in southeastern New Hampshire and recommend corrective measures. Heading the list of water resource problems the resolution addresses is water supply.

Federal interest in the development of natural resources is based on the fact that they are the basis of our national wealth and future well-being. Federal planning in water resources is comprehensive in scope in order to insure that the development and management of the resources provides the optimum benefits obtainable to all the people. Laws governing Federal activities permit some latitude in developing specific plans to be recommended to Congress. This latitude imposes a responsibility on Federal agencies to recommend proper division of responsibility between Federal and non-Federal entities. Proper division of this responsibility will enhance Federal-State cooperation and lead to improved State water resources planning.

Initial workshop meetings were held in order to determine the public's perception of water resource needs and their preferred approach to solving any of these needs. Water supply was far and away the water resource problem that most concerned the public. Generally, people at the community level seemed to prefer to continue with a groundwater approach to providing the needed water. People responsible for water resource planning at the State level, however, seemed to feel that the water supply future rests in developing surface supplies.

Early on in the study an assessment was made of available data. It was determined that insufficient data were available in two specific areas; groundwater and demographics. A consultant was engaged to collect information and screen potential aquifers in the region and then, again under contract, an extensive study was made of all promising aquifers in the area. This study included some field exploration work consisting of seismic and borings. The end product which is carried in a separate consultant report is an engineering estimate of yields on an individual aquifer basis. The other data gap, demographics, was filled by means of a contract which set up a mathematical model to project populations based on the character of the region and its past history. The model was subsequently adopted by the State for making population projections for the entire state. The demographic study is also carried in a separate consultant report.

The Corps then set out to examine potential groundwater or surface water sources both individually and in various combinations. Comparisons were made where more than one solution appeared feasible. Groundwater and surface water were examined on a community-by-community basis. Other methods such as diversion, desalination and water conservation were also considered.

Six plans of improvement are presented in this report. Each represents a basic approach to solving the water supply problem and each plan is presented with an estimated cost of implementation. A preliminary assessment of impacts of implementation in terms of economics, social well-being, and ecology is also presented.

The next step in the study process will be to present these six alternatives to the public. These alternatives will probably be modified and/or supplemented in response to public reaction. Once the final array of alternatives is compiled an exhaustive evaluation will be undertaken so that the State can be presented with all of the information they will need to select an optimum water supply plan for the future.

SOUTHEASTERN NEW HAMPSHIRE

WATER RESOURCES STUDY

STAGE 2 DOCUMENTATION

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SECTION I

INTRODUCTION

## I. INTRODUCTION

This report has been prepared to summarize the water resources investigations of the Southeastern New Hampshire study. The problems identified previously in Stage 1 were water supply, water quality, flood damage reduction, navigation and recreation. They were identified through a series of workshops and meetings with Federal, State, regional and local agency representatives and special interest groups. Further investigations into these problems have revealed major concerns in the area of water supply and water quality. Stage 2, covered in this report, focused primarily on determining the most efficient method of integrating surface and groundwater supplies to optimize use of the area's water resources.

All data necessary to evaluate the short term (2000) and long term (2030) needs of the study area has been obtained from various State and local sources. This information was used to develop a regional profile of environmental, social and economic conditions for the study area.

A wide range of potential measures available to meet the short-term and long term needs of the study area have been identified. These potential measures consist of surface water, groundwater, interbasin diversion and various water conservation measures and have been evaluated in detail. All potential surface water reservoir sites and groundwater aquifers have been developed into various local and regional alternative plans to meet the needs of the study area.

A screening process was employed to eliminate all infeasible alternatives based on economic, social, and environmental impacts. This process will develop a preliminary range of solutions to a level of detailed assessment and evaluation sufficient enough to determine the scope and direction of further planning efforts.

### A. Authority

Recognizing that some states need Federal assistance in developing water resource plans, particularly in urban and urbanizing areas, on 23 September 1976, the Committee on Public Works and Transportation of the House of Representatives at the request of local interests adopted a Resolution authorizing a study to determine the advisability of developing various water resources. The resolution reads as follows:

"Resolved by the Committee on Public Works and Transportation of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the report on Land and Water Resource of the New England-New York Region, transmitted to the President of the United States by the Secretary of the Army on 27 April 1956, and subsequently published as Senate Document Number 14, Eighty-fifth Congress, with a view to determining the advisability of improvements, particularly in the New Hampshire Coastal Area and the Piscataqua River Basin within New Hampshire, in the interest of water supply, flood control, navigation, water quality control, recreation, low flow augmentation, and other allied water uses in this rapidly urbanizing area."

## B. Scope of Study

The Southeastern New Hampshire Water Resources Study is a Level C feasibility study. Results of this study will be available for local, State and Federal use in determining the advisability of improvements in water supply and related water resources needs in the study area.

Data in previous water resources studies was updated and utilized in this study. Additional data was gathered and correlated where no existing information was available.

The level of detail in investigating the alternatives described in this report is appropriate for Stage 2 planning. Individual components in the alternatives are at a compatible level of detail so as to assure an equal assessment of associated impacts. The methodologies and plans presented in this report have been formulated and evaluated in close coordination with other governmental agencies, interest groups and interested individuals.

## C. Study Participants and Coordination

Coordination has been maintained throughout the study with representatives of Federal, State and local agencies as well as concerned individuals. The New Hampshire Water Resources Board has been designated the State Coordinating Agency by the Governor. Numerous meetings have been held to exchange information regarding water resource problems and their potential solutions.

Initial coordination began in April 1978 with a general mailing to Federal, State and municipal officials, interested agencies and individuals. This mailing was undertaken to present the general focus of our study as well as solicit views of water resource problems and concerns in the study area. Several requests for meetings with individual communities, to discuss their water resource needs, were received as a direct result of the general mailing. In August 1978, through the Strafford-Rockingham Regional Planning Council, a series of public workshops was arranged. The purpose of the workshops was to afford the public a chance to discuss specific goals and concerns they thought warranted investigation. Water supply was clearly the greatest concern among those attending the workshops. In particular groundwater development was considered to be an issue that had only been given a cursory look to date. Results of the workshops were publicized through the local electronic and print media. Also, at the request of radio station WKXR in Exeter the Chief of Urban Studies and the Project Manager were featured on a half-hour radio talk show to discuss the study.

Several coordination meetings have been held with the U.S. Fish and Wildlife Service. The Service provided us with a planning aid letter as well as a preliminary assessment of impacts associated with development of the potential reservoir sites.

Coordination with New Hampshire Water Resources Board, the New Hampshire Water Supply and Pollution Control Commission and the Office of State Planning has been maintained throughout the study. Meetings have been held at various stages to discuss the methodologies and assumptions utilized to develop the alternative plans as well as to keep them abreast of study progress.

The public involvement program will continue to be used as an essential guide for further study efforts. Through this program study efforts can be directed at those water resource concerns that study participants feel are the most critical to the area. Efforts will be made to identify special interest groups concerned with various classes of impacts so that these groups or individuals can be specifically consulted during evaluation of the associated impacts of water resource development.

#### D. Prior Studies and Studies of Others

There are a number of Federal, State, regional and local agencies involved in water resources planning efforts for southeastern New Hampshire. A large data base associated with planning in the study area has been compiled. The collected data from both ongoing and completed studies and reports has been utilized during this study to avoid duplication of time and effort. Additional information will also be gathered and correlated for this study.

a. Prior Studies - The need for an integrated cooperative study of the water resources of Southeastern New Hampshire was addressed in the "Draft Plan of Study, Southeastern New Hampshire Water Supply Study" dated July 1975. The plan of study concluded that in order to insure that water resources will be available, for all of the various future needs, it is imperative that regional, and possibly interregional, planning be initiated.

Subsequently, at the request of the New Hampshire Water Supply and Pollution Control Commission, the Office of State Planning, the Water Resources Board and the Corps were asked to assist the State of New Hampshire in a cooperative investigation of the regional water supply of the southeastern region. The joint study was conducted through the provisions of Section 22 of the Water Resources Development Act (PL 93-251). The resulting report, completed in July 1976 entitled "Southeast New Hampshire Water Supply Study", addressed existing water supply source capabilities, future populations and water demands and potential ground and surface water sites.

As a result of this investigation a resolution was proposed by Congressman James C. Cleveland requesting the Board of Engineers for Rivers and Harbors to review the water resources of southeastern New Hampshire and make the appropriate recommendations. This resolution was adopted in September 1976 and work was initiated with fiscal 1978 funds.

b. Studies of Others - Following is a summary of some of the more recently completed planning reports pertinent to the study area.

Piscataqua River and Coastal New Hampshire Basins, Water Quality Management Plan

This report, prepared by the New Hampshire Water Supply and Pollution Control Commission, was authorized under the Federal Water Pollution Control Acts Amendments of 1972, P.L. 92-500, Section 303 (e) and the New Hampshire Continuing Planning Process. The purpose of this study was to determine a course of action to restore and/or maintain the chemical, physical and biological integrity of the waters of the Piscataqua River and coastal New Hampshire basins.

North Atlantic Regional Water Resources (NAR) Study

Published in June 1972 by the Army Corps of Engineers, this study examined a wide variety of water and related land resources, needs and desires in formulating a broad and coordinated program to guide future resource development and management in the North Atlantic Region. This Level A study was authorized by the 1965 Water Resources Planning Act (P.L. 89-80) and the 1965 Flood Control Act (P.L. 89-298) and was carried out under guidelines set by the Water Resources Council.

The recommended program and alternatives developed for the North Atlantic Region were prepared under the direction of the NAR Study Coordinating Committee, a partnership of resource planners who represent some 25 Federal, regional and State agencies. The study area consisted of 13 northeastern states including all of New England. The NAR study report presents the recommended program and the alternatives as a framework for future action based on a planning period running through 2020, with benchmark planning years of 1980 and 2000. The NAR study includes southeastern New Hampshire in part of the region identified as Area 6 and a small part of Area 7.

Southeast New Hampshire Water Resources Study, Comparison and Evaluation of Earlier Identified Reservoir Sites

Published in April 1978 by the Army Corps of Engineers, the purpose of this investigation was to review sites proposed for surface supply reservoirs. Each site was evaluated on the basis of engineering, environmental, economic and social aspects. The information obtained and developed from this investigation is to be used in the decision process regarding short and long range planning.

Northeastern United States Water Supply Study, Merrimack River Basin Water Supply Study

The studies presented in this report, issued by the Army Corps of Engineers in January 1977, are directed toward developing a plan for utilizing the Merrimack River as a water supply source for eastern Massachusetts and possibly southeastern New Hampshire. All reasonable alter-

native plans to solve the region's future water supply problems were considered and several plans studied in detail including economic, environmental and socioeconomic effects. All of the plans were also evaluated to determine their compatibility with the development of a regional plan.

Hydroelectric Potential At Existing Dams New England Region,  
Volume 1 - Appendix D

Completed in May 1979 this report provided information on the potential of developing new or abandoned hydroelectric sites as a means of providing an economical or viable means of reducing electric rates and oil dependency in New Hampshire. The second volume will accentuate the optimum potential redevelopment of existing sites currently in operation and development of new hydroelectric sites. Power was assumed to be the primary and single purpose objective with other interrelated water resources use being currently held in abeyance.

Assessment of Low Flows on Streams in New Hampshire

This investigation is being conducted at the request of New Hampshire State Officials through the provisions of Section 22 of the Water Resources Development Act (P.L. 93-251) scheduled for completion in December 1980, the report will include an analysis of streamflow data to determine low flow frequencies and durations for ungaged streams. The report will also identify existing water resource projects having significant effect on low flows.

New Hampshire Water Resources Board Report on Metropolitan Water  
Supply for Seacoast Area

This study, completed in October 1960 by Camp, Dresser and McKee, Inc., addressed the present and future water supply problems of those communities within a radius of approximately twelve miles of the Bellamy Water Treatment Plant in Madbury. The report identified those communities with a need for additional supplies and evaluated the feasibility of developing a Metropolitan System. In addition to expansion of the Madbury Plant, the final recommendation proposed development of the Isinglass Reservoir.

Public Water Supply Study

Anderson-Nichols, Inc. conducted this two-phase study. Phase one completed in 1969 and phase two, a more detailed report utilizing data from phase one, was completed in 1972. The recommendations in both these reports called for a diversion from the Merrimack River and Lake Winnepesaukee as additional water supply sources.

Water Quality Management Plan and Environmental Impact Statement  
for the Southern Rockingham 208 Project

This report was prepared by the Southern Rockingham Regional Planning District Commission and was completed in April 1980. It addresses the water quality problems of a seven community area in southeastern New Hampshire and makes recommendations of management measures to achieve 1983 water quality goals.

New Water Supply Sources and Improvements, City of Dover

This report was completed in November 1979 by Camp, Dresser and McKee Inc., for the Board of Water Commissioners, city of Dover. It provides a comprehensive engineering investigation of new water supply sources for the city. It recommends a three stage plan to meet short term and long term water supply needs including development of additional groundwater (Stage I), diversion of water from the Isinglass River to recharge groundwater aquifers (Stage II) and development of a regional water supply from a surface water reservoir on the Isinglass River (Stage III).

Land Use Plan - A Citizen's Synopsis

Strafford Rockingham Regional Council, 1977.

Southern Strafford Region - An Environmental Planning Study

Strafford Rockingham Regional Planning Commission, 1976.

In addition to the reports cited above, there are water resource studies currently underway in many of the individual communities. Results of these investigations will be incorporated as they become available.

E. The Report

This report presents findings of the study through Stage 2.

SECTION II

PROBLEM IDENTIFICATION

## II. PROBLEM IDENTIFICATION

This section presents background information about existing conditions along with the most probable future expected without Federal action. The information is then analyzed to identify problems, needs and opportunities for the study area.

### A. Study Area

The study area, shown on Plate 1, encompasses 50 communities<sup>1/</sup> and approximately 1000 square miles in southeastern New Hampshire. All New Hampshire communities that fall within the Piscataqua River Basin and the New Hampshire Coastal Area, as well as the communities of Atkinson, Hampstead, Newton, Plaistow, Salem, South Hampton, Hudson, Pelham and Windham in the Merrimack River Basin, are included in the study. Overall, the study area accounts for 12.8 percent of the total land in New Hampshire. It is bounded on the north by the Saco River Basin, on the northeast by the Maine coastal area, on the southeast by the Atlantic Ocean and on the south and west by the Merrimack River Basin. It has a maximum north-south length of about 65 miles and a maximum width of about 35 miles.

The Piscataqua River Basin has a total drainage area of 1,022 square miles, 776 of which are in New Hampshire. The Piscataqua and its largest tributary, the Salmon Falls River, form the boundary between New Hampshire and Maine. The other major rivers within the Piscataqua Basin, shown on Plate 1, are the Bellamy, Cocheco, Lamprey and Exeter.

The coastal area has a total drainage area of 55 square miles. It includes all of the drainage entering the Atlantic Ocean between Odiorness Point in Rye (the south entrance to the Piscataqua River) and the southern end of Seabrook Beach at the Massachusetts state line. The most important waterway is Hampton Harbor. It occupies about half a square mile of the extensive saltwater marsh along the southeastern part of the coast. Hampton Harbor is fed by two small rivers, the Blackwater, entering from the south, and the Hampton, entering from the northwest.

The remaining drainage area is within the Merrimack River Basin. It takes in virtually all of Atkinson, Hampstead, Newton, Plaistow, Salem, South Hampton, Hudson, Pelham and Windham and well over half of Danville, East Kingston and Kingston.

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<sup>1/</sup> In December 1978, subsequent to a series of public workshop meetings, Corps and State of New Hampshire representatives met to discuss possible regional water supply systems in southeastern New Hampshire. They concluded that the communities of Hudson, Pelham and Windham in the Merrimack River Basin should be part of any regional solutions proposed for the Salem-Plaistow area. Therefore, the State of New Hampshire has requested that the Corps of Engineers include these communities in its Southeastern New Hampshire Water Resources Study Area. The Corps has addressed these three communities in addition to the 47 previously authorized.



## 1. Geology and Topography

The topography of the study area varies considerably. The entire New Hampshire coastal area is a flat or gently rolling plain of very low relief with a poorly defined divide separating this drainage area from adjoining basins. The elevation of the divide is generally less than 60 feet above sea level. A group of drumlins, low hills composed of glacial till, that reach 200 feet or better form the western divide. Apart from the drumlin belt, few other places in the coastal area exceed an elevation of 80 feet. The coastal area is in a mature stage of development; however, the topography is largely a product of marine submergence and glaciation.

The northern portion of the Piscataqua River Basin, in contrast to the coastal area, has high hills and low mountains rising above wide swampy valleys. The valleys here are generally above 500 feet while mountain elevations reach 1,100 feet or more. The remainder of the basin is characterized by rolling to flat lowlands, which blend with the coastal area and have elevations generally less than 100 feet and seldom exceeding 300 feet. Copple Crown Mountain, located on the basin divide in Brookfield, is the highest point in the study area at an elevation of 1,876 feet. Because of this diverse topography, land use patterns vary from forest-town at the head of the Salmon Falls River to urban strip extending from Rochester to New Castle and down the coast to Seabrook. Most of the study area is farm-forest with town centers generally 4 to 5 miles apart. The main commercial and service trade centers are Portsmouth, Dover, Rochester, Exeter and Hampton. The surficial geology of the basin consists of various deposits and materials characteristic of glaciation and marine submergence. Glacial till blankets the very irregular bedrock surface. Most of the bedrock originally crystallized deep in the earth from magmatic intrusions during the early Paleozoic era. Since that time, geological forces have changed and shaped the land so that the bedrock is near to or outcropping at the surface.

Unconsolidated sediments deposited from ice can be divided into two general classes: till and stratified drift. The glacial till is generally composed of poorly sorted sediments, ranging in size from clay and silt to coarse gravels and some boulders. Till is highly impermeable and commonly called "hard pan." The till in the study area, which overlies the bedrock, is generally less than 15 feet deep. Numerous small lakes, ponds and marshes occupy depressions in the glacial till that blankets the upland valleys. These extensive fresh and saltwater marshes cover nearly one-third of the coastal area's surface.

The stratified drift deposited by melting water is characterized by layering or stratification of medium to well sorted sediments. One kind of stratified drift, termed ice contact drift, is deposited on or next to blocks of stagnant ice. In the southeastern New Hampshire study area ice contact drift generally consists of stratified sands and gravels, ranging

in thickness from less than one foot to greater than 190 feet. Another kind of stratified drift is called outwash and is formed from melt water streams flowing over the land in front of the retreating margin of the ice sheet. The generally good degree of sorting of these sediments allows for the high coefficient of permeability characteristic of the medium to coarse grained deposits of stratified sand and gravel. The thickest deposits of this drift are found in the study area's low lying areas and valleys. Farther up in the valley walls the stratified drift deposits thin and give way to exposures of till.

Marine deposits of Pleistocene and more recent sediments are the other unconsolidated sediments in the study area. The Pleistocene deposits that formed as the sea rose and re-advanced over the land in response to glacial melting are similar in lithology, texture and appearance to outwash deposits. These marine deposits are confined to the eastern part of the study area and commonly rest on till or bedrock and outwash deposits. The marine deposits do not extend more than approximately 20 miles inland or above the 200-foot contour line. The recent deposits consist chiefly of a thin layer of eolian sediments, alluvial material and recent beach deposits.

## 2. Climate and Hydrology

The climate of the study area is characterized by four distinct seasons with variable weather. Summers are relatively cool and winters are severe, especially at the inland points. The average annual temperature is about 46°F at the headwaters to the north and about 50°F at points in the coastal area. Average monthly temperatures vary widely throughout the year, from 68° to 73°F in July and August to 18° to 27°F in January and February.

The study area lies in the path of the "prevailing westerlies" and the cyclonic disturbances that cross the country from west or southwest towards the east or northeast. The area is also subjected to occasional violent coastal storms, some of tropical origin, that travel up the Atlantic seaboard. These tropical storms, sometimes known as "nor'easters," are heavily laden with moisture from the ocean; but a great deal of their energy is dissipated before reaching northern New England.

The mean annual precipitation here is 41 inches, and this is distributed fairly uniformly throughout the year at a rate of approximately 3 inches per month. Geographically, the average precipitation varies from a minimum of 38.2 inches at Massabesic Lake in the southwestern portion of the basin to a maximum of 43.3 inches in the northwestern portion of the Piscataqua River Basin.

Table 1 summarizes precipitation data at selected U.S. Weather Bureau stations. The range between maximum and minimum values of average monthly precipitation at any location is about one or two inches, indicating there are no pronounced dry or wet seasons for the area.

TABLE 1

AVERAGE PRECIPITATION (in inches)\*

	<u>Durham</u>	<u>Massabesic Lake (1)</u>	<u>Newburyport Mass. (1)</u>	<u>New Durham**(1)</u>
Period of Record	1941- 1970	1941- 1970	1941- 1970	1951- 1960
Elevation m.s.l.	70	250	20	650
January	3.32	2.83	3.48	3.71
February	3.13	2.53	3.32	3.34
March	3.53	2.80	3.68	4.28
April	3.33	2.98	3.46	3.64
May	3.48	3.41	3.64	3.73
June	3.04	3.15	2.83	3.03
July	3.33	3.81	3.46	2.72
August	3.17	3.27	3.13	2.93
September	3.16	3.04	3.56	3.90
October	3.30	3.02	3.29	3.48
November	4.89	4.14	4.98	4.16
December	<u>3.87</u>	<u>3.25</u>	<u>4.19</u>	<u>4.34</u>
Annual	41.55	38.23	43.02	43.26

SNOWFALL\*\*

	<u>Portsmouth</u>	<u>Durham</u>	<u>Haverhill Mass. (1)</u>	<u>Lakeport (1)</u>
Years of Record	6	61	58	21
Elevation (m.s.l.)	40	70	60	560
Average Annual Snow- fall (inches)	54	56	53	81

\* U.S. Department of Commerce, Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1941-70 - Climatology of the U.S. No. 81 (New England).

\*\* U.S. Department of Commerce, Climatic Summary of the U.S., Supplement for 1951-1960 New England, No. 86.23, Washington 1964.

(1) In Merrimack River Basin.

Approximately one half or 20 inches, of the annual precipitation either flows overland into surface water bodies or percolates through the ground to the water table. The remainder is lost through evapotranspiration. Although the rate of precipitation is fairly uniform throughout the year, the summer is drier than other seasons. This results from the higher rate of evapotranspiration during the warm weather. Most groundwater eventually discharges at the earth's surface into rivers, ponds, springs and other surface water bodies, and groundwater discharge produces the dry weather flows of streams and brooks. It is important to realize the interrelationship and interdependence of these components of the water system.

### 3. Population

In 1970, 207,000 persons lived in the Southeastern New Hampshire (SENH) study area, accounting for 28.1 percent of the state's total population. However, the study area covers only 11.5 percent of the state's total land area. Southeastern New Hampshire has undergone dramatic population growth in recent years, increasing from a population of 157,000 in 1960 to 207,000 in 1970, to 250,000 in 1977, showing a total growth of 62.8 percent. This rapid growth was primarily due to influx of industry into the area and expanding role for the area as a bedroom community for the greater Boston area. Growth in coastal activity also made a contribution.

Table 2 displays the population changes in the study area communities over the 1960 to 1970 decade, and between 1970 and 1980. Dover, Portsmouth and Salem are the only communities in the study area with populations over 20,000. While Dover and Portsmouth have shown modest growth between 1960 and 1977. Salem's population skyrocketed to over 25,000 in 1977 from a 1960 population of 9,210 a 176 percent increase. Several communities surrounding Salem showed similar surges in population including Atkinson, Pelham and Windham.

The communities showing the slowest growth rates over this period are for the most part those located along the Maine border including Rollinsford, Sommersworth, and New Castle. Newington, the only study area community showing a population loss between 1960 and 1977, is also located along the New Hampshire/Maine border.

Table 3 shows the density of the study area communities. Sixteen of the study area communities have population densities of less than 100 persons per square mile. Communities with some of the lowest densities are concentrated in the upper portions of the study area. Overall, densities ranged from as low as 15 persons per square mile in Brookfield to a high of 1,876 persons in Portsmouth. The other communities showing densities in excess of 1000 persons per square mile were New Castle, Salem and Somersworth.

TABLE 2

POPULATION GROWTH

<u>COMMUNITY</u>	<u>1960</u>	<u>1970</u>	<u>1977</u>	<u>1980</u>	<u>PERCENT CHANGE 1960-1970</u>	<u>PERCENT CHANGE 1970-1980</u>
Atkinson	1,017	2,291	3,394	5,082	125.3	121.8
Barrington	1,036	1,865	3,518	4,473	80.0	139.8
Brentwood	1,072	1,468	1,822	2,012	36.9	37.1
Brookfield	145	198	345	431	36.5	117.7
Candia	1,490	1,997	2,549	2,615	34.0	30.9
Chester	1,053	1,382	1,910	2,800	31.2	102.6
Danville	605	924	1,222	1,486	52.7	60.8
Deerfield	714	1,178	1,717	2,657	64.9	125.6
Dover	19,131	20,850	22,376	22,014	9.0	5.6
Durham*	5,504	8,869	9,248	12,706	61.1	43.3
East Kingston	574	838	1,046	1,003	46.0	19.7
Epping	2,006	2,356	2,701	3,174	17.4	34.7
Exeter	7,243	8,892	10,429	11,395	22.8	28.1
Farmington	3,287	3,588	4,068	3,762	9.1	4.9
Fremont	783	993	1,269	1,719	26.8	42.2
Greenland	1,196	1,784	2,000	1,767	49.2	-1.0
Hampstead	1,261	2,401	3,365	5,141	90.4	114.1
Hampton	5,379	8,011	9,717	10,098	48.9	26.1
Hampton Falls	885	1,254	1,415	1,750	41.7	39.6
Hudson	5,876	10,638	12,595	13,378	81.0	25.8
Kensington	708	1,044	1,251	1,145	47.5	9.7
Kingston	1,672	2,882	3,803	4,233	72.4	46.9
Lee	931	1,481	1,748	1,791	59.1	20.9
Madbury	556	704	866	952	26.6	35.2
Middleton	349	430	482	606	23.2	40.9
Milton	1,418	1,859	2,356	2,222	31.1	19.5
New Castle	823	975	954	1,105	18.5	13.3
Newfields	737	843	813	1,090	14.4	29.3
Newington	1,045	798	614	771	-23.6	-3.4

TABLE 2 (continued)

<u>COMMUNITY</u>	<u>1960</u>	<u>1970</u>	<u>1977</u>	<u>1980</u>	<u>PERCENT CHANGE 1960-1970</u>	<u>PERCENT CHANGE 1970-1980</u>
Newmarket	3,153	3,361	3,661	3,764	6.6	12.0
Newton	1,419	1,920	2,895	3,400	35.3	77.1
North Hampton	1,910	3,259	3,504	3,730	70.6	14.5
Northwood	1,034	1,526	1,971	2,514	47.6	64.7
Nottingham	623	925	1,578	1,722	48.5	86.2
Pelham	2,605	5,408	8,069	8,117	107.6	50.1
Plaistow	2,915	4,712	5,589	5,487	61.6	16.4
Portsmouth**	25,833	25,727	28,517	24,050	-0.4	-6.5
Raymond	1,867	3,003	4,614	6,425	60.8	114.0
Rochester	15,927	17,928	19,979	20,937	12.6	16.7
Rollinsford	1,935	2,273	2,073	2,625	17.5	15.5
Rye	3,244	4,083	4,460	4,701	25.9	16.1
Salem	9,210	20,142	25,455	26,706	118.7	32.6
Sandown	366	741	1,596	2,055	102.5	177.3
Seabrook	2,209	3,053	5,331	7,586	38.2	148.5
Somersworth	8,529	9,026	10,174	9,618	5.8	6.6
South Hampton	443	558	694	615	25.9	10.2
Strafford	722	965	1,417	1,176	33.6	21.9
Stratham	1,033	1,512	2,022	3,012	46.4	99.2
Wakefield	1,223	1,420	2,358	2,341	16.1	64.9
Windham	1,317	3,008	4,720	6,319	128.4	110.1
<b>TOTALS</b>	<u>156,013</u>	<u>207,343</u>	<u>250,270</u>	<u>270,574</u>	<u>32.9</u>	<u>30.5</u>

NOTES: \* Includes dormitory residents at University of New Hampshire.  
 \*\* Includes population of Pease Air Force Base.

TOTAL STATE                      709,264      877,592

TABLE 3

POPULATION DENSITY OF STUDY AREA COMMUNITIES 1977

<u>COMMUNITY</u>	<u>LAND AREA (sq mi)</u>	<u>PERSONS PER (sq mi)</u>	<u>COMMUNITY</u>	<u>LAND AREA (sq mi)</u>	<u>PERSONS PER (sq mi)</u>
Atkinson	11.0	308	Milton	33.4	70
Barrington	47.1	74	New Castle	0.8	1,192
Brentwood	16.8	108	Newfields	7.1	114
Brookfield	23.0	15	Newington	8.1	75
Candia	29.9	85	Newmarket	12.3	297
Chester	26.0	73	Newton	9.8	295
Danville	11.6	105	North Hampton	13.8	253
Deerfield	50.9	33	Northwood	27.9	70
Dover	26.0	860	Nottingham	46.0	34
Durham	23.3	396	Pelham	26.7	302
E. Kingston	9.8	106	Plaistow	10.5	532
Epping	26.2	103	Portsmouth	15.2	1,876
Exeter	19.5	534	Raymond	28.9	159
Farmington	37.4	108	Rochester	46.7	427
Fremont	17.2	73	Rollinsford	7.6	272
Greenland	11.1	180	Rye	12.6	353
Hamptstead	13.6	247	Salem	24.5	1,038
Hampton	13.2	736	Sandown	13.8	115
Hampton Falls	12.2	115	Seabrook	9.0	592
Hudson	29.5	426	Somersworth	10.1	1,007
Kensington	11.8	106	South Hampton	7.8	88
Kingston	19.5	195	Strafford	50.0	28
Lee	20.3	86	Stratham	15.2	133
Madbury	13.9	62	Wakefield	40.0	58
Middleton	18.2	26	Windham	26.3	179

#### 4. Economy

The Industrial Revolution substantially changed a good part of SENH from an agricultural region into an industrial area. Textile manufacturing became the major economic force in many communities, with textile mills springing up on fast-flowing rivers and estuaries such as the Merrimack and Piscataqua. In addition to increasing the region's wealth, the thriving mills expanded its population both in numbers and diversity.

Over the past few decades a variety of industries have been established with a concentration of activities in the communities of Portsmouth, Dover, Rochester, Somersworth, Exeter, and Seabrook. Particularly important are the manufacturing of shoes, electronic products, electrical equipment, automotive accessories, printing machinery and woolen goods. Table 4 shows the contribution of the major industries to the total income of the region. These figures generally follow the same direction as the national trends with one exception. The wholesale and retail trade sector's contributions have shown an overall increase between 1950 and 1980, whereas, nationwide they have declined 15 percent. Losses in the manufacturing sector, however, were much greater than those experienced on the national level. On the other hand growth within the contract construction sector and the finance, insurance and real estate sector far exceeded the increasing nationwide trend.

TABLE 4

PERCENT CONTRIBUTION OF REGION'S INDUSTRIES TO TOTAL EARNINGS

<u>Sector</u>	<u>1950</u>	<u>1962</u>	<u>1970</u>	<u>1980</u> <u>(Projections)</u>
Agriculture & Forestry	5.35	1.71	1.39	1.14
Fisheries & Mining	*	0.03	0.05	0.07
Contract Constructor	4.27	5.75	5.98	6.40
Manufacturing	41.58	29.44	28.33	27.23
Transportation, Communication & Public Letters	3.93	3.43	3.28	3.46
Wholesale & Retail	14.88	13.95	15.50	16.08
Services	10.29	11.55	13.73	16.73
Finance Insurance & Real Estate	1.93	2.35	3.08	3.71
Government	17.43	31.76	28.68	25.15

\* Less than 0.01

In general, the economy in the study area is characterized by a slowdown in the rate of growth of the manufacturing sector and a growing service base. The region's traditional nondurable goods industries, particularly textiles, leather, food processing and apparel, have declined considerably. Employment in this category dropped by 25 percent or 310,000 persons between 1950 and 1970, with about a third of this occurring between 1960 and 1970. The major durable industries including electrical machinery, transportation equipment, fabricated metals and instruments, have shown a slight increase. The more rapid decline in nondurables and the less rapid rise in durables is one of the major explanations for the region's poor economic record.

Employment totals for Strafford and Rockingham counties have been utilized as representative of the study area. Overall, employment for these two counties rose by 87 percent between 1970 and 1978. Data is displayed in Table 5. In 1978, the nonmanufacturing sector was the larger source of employment, showing an increase of 138 percent over 1970 figures. During this time the proportion of total employment increased from 48.1 percent to 61.3 percent. The manufacturing sector, the larger source of employment in 1970 continued to show growth to 1978, but at a much slower rate than that shown by the nonmanufacturing sector. The trade sector continued to dominate the nonmanufacturing sector, accounting for 30 percent of total employment, showing growth over 100 percent between 1970 and 1978.

The services sector showed the largest growth of 257 percent over the eight-year period. This may be attributed to the presence of Portsmouth, the major commercial and service center in the region, and the county's seacoast region where tourist services make up a sizeable percentage of employment. The region's rate of employment in service industries has followed the overall New England trend which has been rising more rapidly than that for the nation.

TABLE 5

EMPLOYMENT BY SECTOR  
STRAFFORD AND ROCKINGHAM COUNTIES

	<u>1970</u>	<u>PERCENT OF TOTAL</u>	<u>1978</u>	<u>PERCENT OF TOTAL</u>
Manufacturing	20,114	52.0	27,985	38.7
Durable	7,887	20.4	15,415	17.4
Nondurable	12,227	31.7	12,570	21.3
Nonmanufacturing	18,604	48.1	44,329	61.3
Construction & Mining	1,900	4.9	5,888	8.1
Transportation, Communication & Utilities	1,642	4.2	2,029	2.8
Trade	10,394	26.8	21,768	30.1
Finance, Insurance, & Real Estate	1,411	3.6	3,006	4.2
Services	<u>3,257</u>	8.4	<u>11,638</u>	16.1
TOTAL	38,718		72,314	

In 1970, the manufacturing sector accounted for 52 percent of employment opportunities, dropping to 38.7 percent by 1978. The largest growth in manufacturing was in durable goods, where the machinery, electrical, rubber and plastics industries have shown sizeable increases. Employment in durable goods industries rose by 95 percent, and in nondurable goods it increased by 2.8 percent.

## 5. Natural and Cultural Resources

As a region with several rivers and a coast, many of the natural and cultural areas in the region are water related. Natural areas consist of resources such as unusual geologic and hydrologic areas and unique flora and fauna. Some of this unique flora and fauna are listed in the Federal Register of threatened and endangered species. Examples of natural landmarks are the Drowned Forest at Odiorne's Point in Rye and Great Boar's Head in Hampton. Cultural areas include historic structures, sites and districts on local, State and national registers as well as important archaeological and educational structures such as museums. These natural and cultural sites not only add to the diversity of the overall environment but also place limitations and requirements on nearby development possibilities and patterns.

New Hampshire is famous for its freshwater game fishing. Many of the larger lakes contain both cold and warm water varieties. Brook, rainbow and lake trout, land-locked salmon, golden trout, bass, pickerel and pike are some of the most popular game fish. Most fishing areas are easily accessible by good roads and have modern boat launching facilities. Ice fishing bob-houses dot the lakes during the winter.

Deer, bear, grouse, woodcock, ducks, pheasant, snowshoe hare, squirrel, raccoon, fox, bobcat and woodchucks are among the hunted animals. The variety of native game birds provide good upland bird and waterfowl shooting. The most important fur bearing animals in New Hampshire are bobcat, beaver, fisher, mink, muskrat and raccoon. Black bear have become more numerous and their range is extending southward in the State. The white-tailed deer attracts more hunters to New Hampshire than any other game animal.

There are 296 species of land and water birds in New Hampshire. In the saltmarshes and tidal areas along the seacoast the herons, egrets, waterfowl, sandpipers, plovers, gulls and terns. The New Hampshire Audubon Society organizes coastal tours as well as trips to the Isles of Shoals where rare land and ocean birds can often be seen.

Programs for listing the animals which are endangered, threatened or of special concern have been developed by the U.S. Fish and Wildlife Service, Department of Interior. The lists are intended to protect the named species and to make the public aware of the general plight of these particular animals. Lists of the endangered species are published in the Federal Register as directed by the Endangered Species Act of 1973.

## 6. Land Resources

The best available land use data is that provided by the regional planning commissions. Parts of four such commissions encompass the SENH study area communities. Forty-two communities within the study area fall within the Strafford-Rockingham Regional Council (SRRC). The communities of Candia, Chester, Deerfield, and Raymond fall within the Southern New Hampshire Planning Commission (SNHPC) area, Pelham and Hudson in the Nashua Region Planning Commission (NRPC) area, and Brookfield and Wakefield in the Lakes Region Planning Commission (LRPC) area.

Emphasis will be placed on land use trends in the SRRC as being fairly representative of the SENH study area. Significant divergences of the communities outside the SRRC will be indicated.

At present, land use and vegetative cover in the SRRC area breaks down as follows:

<u>LAND USE</u>	<u>PERCENT OF LAND</u>
Residential	6.9
Commercial	1.1
Industrial	0.3
Extractive	0.4
Recreational	0.2
Agriculture	11.4
Open Space	
Woodlands	79.0
Institutional	<u>0.7</u>
TOTAL	100.0

Of the total acreage, the majority, by far, has been classified as woodland, with agriculture/open space following second. Residential uses make up the largest segment of developed land, accounting for close to 7 percent as indicated in the table above. Development has taken place in the major communities in the region, specifically Salem, Exeter, Hampton, Portsmouth, Dover, Durham, Rochester, and Somersworth. Development has also spread along major highway corridors, including Route 125 running through Plaistow north from the Massachusetts border, Route 1 along the seacoast, Route 16 through Dover and Rochester, and along Route 28 through Salem. Other than this, development is generally dispersed, moving from a higher density in the southern portion of the region to less dense development in the north.

The other three planning regions are like the SRRC area with approximately 80 percent of their land areas falling within the forest or vacant land categories. The proportion of vacant land within Candia, Chester, Deerfield and Raymond exceeds 80 percent, approximating close to 91 percent in both Chester and Raymond.

a. Water Related Land - Lands adjacent to water are quite valuable. However, wetlands, beaches and dunes, groundwater recharge areas, flood plains, agricultural lands and certain unique or cultural areas have limited development capability for a number of reasons. Deciding whether such lands should be developed or conserved involves weighing the social, economic and environmental benefits of development against the benefits of preservation.

One of the most fragile of these is wetlands. The State of New Hampshire now has legislation aimed at protecting wetlands from development that could interfere with their natural functions.

Inland wetlands recycle nutrients, serve as nursery areas, provide habitat for wildlife and serve, in many cases, as natural storage areas for high stream flows, releasing them slowly and modifying downstream flood stages. Alteration of this delicate balance of water, land and vegetation could possibly diminish the ability of wetlands to perform these functions.

Coastal wetlands are thought to enhance water quality because of the flushing action of changing tides. The water quality benefits of inland wetlands are less certain because the decaying vegetation in them increases oxygen demand; however, they may improve water quality in rivers when they gradually release stored floodwaters by providing a more uniform flow.

The coastal beaches, dunes and bluffs along the southeastern New Hampshire coast attract large numbers of visitors annually. They also form a line of defense against coastal storms and tidal flooding. Development of these often eroding lands has, in many cases, affected both their popularity and defensive capability.

Potential groundwater as well as surface water sites must be shielded from development. Pollutants can enter the ground at certain sites and filter directly into water supplies. As development encroaches on groundwater recharge areas, the potential for water quality deterioration increases. Protecting these recharge areas, particularly in communities that rely upon groundwater as their source of water, is imperative if the supplies are to be available for future use. Some activities within the SENH area which impact on groundwater quality are highway salting operations, industrial waste discharge, "natural" concentrations of iron and manganese and sanitary landfills.

Tidal rivers and their associated saltwater wetlands are also vulnerable to deterioration and outright destruction from careless land use practices. Tidal rivers and tidal length in the SENH area are the Bellamy (4 miles), the Lamprey (2 miles), the Salmon Falls (3.7 miles) and the Hampton (2 miles). It has been reported that 70 percent of New England's

commercially valuable fish species are either directly or indirectly dependent upon estuaries at various stages of their life cycles. While offshore species may never physically enter estuarine waters, they feed on the many that do so; they are tied to estuarine habitats by the food chain. Unfortunately, these species would be threatened by continued loss of coastal habitats and pollution of coastal waters.

Some water-related lands retain their usefulness under limited kinds of development. Flood plains, for example, are capable of supporting certain forms of development, including agriculture and recreation. Such development could be designed to neither impede natural flood flows nor incur substantial damages if flooded. Large scale development in flood plains within the study area has increased the potential for heavy flood damages.

b. Transportation -- Changes in transportation have affected the growth of the State. In 1796, the "turnpike era" began with the charter of the first turnpike, 35 miles long, between Durham and Concord. Better bridges were built, coach routes were established (the first Concord Coach was built in Concord in 1826-27), and hostleries were built. In 1835 railroads began replacing waterway travel and shipping, and in the latter half of the 19th century, the railroad became the key transportation link between cities, towns and farms.

It was in the later 1800's that the railroads were built into the scenic lakes region and through the mountain notches into the north country, opening a vast area of New Hampshire to the travelling public. Affluent residents of the cities of the Northeast were made aware of the beauty of the New Hampshire countryside and became interested in extended vacationing in New Hampshire. The concept of the extended vacation and the "Grand Hotel" came into being throughout New England.

With the simultaneous rise of the automobile and the middle class, vacation patterns changed. The hotels were closed and replaced by motels, camping areas, and second or vacation homes.

In 1950 New Hampshire recognized the need to update highway systems for industrial and recreational development and began modern turnpike construction. Interstate 95 connects Boston, Massachusetts, with Portsmouth, New Hampshire, and continues north into Maine along the seacoast. The Spaulding Turnpike serves as a major connector between Rochester, New Hampshire and Portsmouth. State Route 101 is the principal east-west route in the State, connecting Keene with the seacoast. The highway system in New Hampshire allows for fast efficient north-south traffic flow connecting the south with southern New England. The movement from east to west, however, is much more difficult.

Inter-city buses represent an alternative mode of mass transportation that is, of course, largely dependent on the existing highway network. Regularly scheduled bus services, in varied and limited degrees, are offered by more than a dozen bus line companies in and between the communities in the most densely populated southern area of the state. These companies

are mostly small businesses serving the locales near their headquarters, but at least four of them are regional carriers providing interstate and limited statewide service. In addition, a number of other bus companies in the state's major communities offer services limited to special charter.

Despite the steady decline in rail passenger services since World War II, interest in railway commuter routes has remained high, especially, again, in the more populous southern part of the state. In January of 1980 passenger service was initiated between Concord and Boston as a two-year experiment funded solely by a U.S. Department of Transportation grant. The backbone of rail transportation as it exists in New Hampshire today is in the form of freight hauling over the Boston and Maine Corporation's line from Boston and other points south, through south-central New Hampshire to White River Junction, Vermont. Although the major activity has been the hauling of fuel to electric power generating facilities, this rail service has contributed substantially to the development of several major new industries along its route in New Hampshire in recent years.

The existing status of mass transportation in New Hampshire would appear to reflect the fact that New Hampshire is basically a rural state and that the successful development, on a competitive basis, of mass transportation facilities will depend to a great extent upon increases in the potential market brought about through increased population growth. Additional factors that may come to bear may be legal controls to limit private vehicular use and the total demand on overall energy resources. Aside from the overall lack of demand for mass transportation services, the competition working against rail passenger services is heightened by the quite reasonable cost of existing interstate certificated air service and bus transportation. Until mass transportation facilities are designed and demonstrated to be less expensive and less time-consuming than automobiles, and to offer a comparable degree of traveller options as to destinations and trip schedules, it seems reasonable to assume that highways will continue to be New Hampshire's primary means of travel.

Since early colonial days, New Hampshire's development has been closely allied with water transportation, and although its impact on the total New Hampshire economy has been reduced, the City of Portsmouth and the Piscataqua River provide important commercial port facilities. Portsmouth is the only natural deep water harbor between Boston, Massachusetts, and Portland, Maine. Portsmouth Harbor and the mouth of the Piscataqua River combine to offer tidewater sites on seven miles of ice-free navigable waters.

#### B. Without Project Projection

This section describes the most probable future expected for the study area under the assumption that no new Federal water resources projects will be developed in Southeastern New Hampshire. Alternative futures presented in the report are assessed and evaluated by comparison to the "without project" condition.

1. Population Projections - The population of the 50 community study area is projected to increase from 207,000 in 1977 to 536,000 in 2030, an increase of 160 percent. Table 6 illustrates the population projections for each community over this time frame, and the percent change from 1960 to 1970 and from 1970 to 1980.

Ten study area communities show future populations increasing at a rate exceeding 200 percent, ten with populations growing at a rate under 100 percent, with the remainder of the study area communities showing growth between 100 and 200 percent. The fastest growing communities are fairly small with 1975 populations under 5,000, those communities having smaller changes generally were larger, with 1975 populations ranging from 1,224 to 24,781.

Of the ten largest communities in 1975, nine are projected to remain in the top ten in 2030. Salem is projected to replace Portsmouth as the largest community in the study area. Half of the ten communities projected largest in 2030 also rank within the category of the ten slowest growing communities. The ten largest communities in 2030 are displayed below.

TEN LARGEST COMMUNITIES IN 2030

	<u>Ranking in 1975</u>	<u>2030 Population</u>
1. Salem	2	54,674
2. Portsmouth	1	47,807
3. Dover	3	39,012
4. Rochester	4	37,153
5. Exeter	7	23,386
6. Durham	6	22,688
7. Hampton	9	20,811
8. Hudson	5	19,769
9. Somersworth	8	17,082
10. Seabrook	-*	15,527

\*Seabrook replaced Pelham as the 10th largest.

2. Future Growth - The land use plans from the four planning commissions encompassing the 50 study area communities provide a general view of what the study area may look like in the year 2000 based upon projected populations, existing land use, land capability and existing town plans and zoning ordinances. The portions of the region which are expected to undergo significant development lie under the jurisdiction of the Strafford-Rockingham Regional Council, which covers the majority of the study area. Major industrial development is expected to occur in three areas, one centering on Portsmouth, another located in Seabrook, and a third located along Route 101 in Exeter, Brentwood, and Epping. Development on a smaller scale is expected to exist in other areas but will not be of primary importance.

TABLE 6  
POPULATION ESTIMATES

COMMUNITY	1960	1970	1977	1980	1990	2000	2010	2020	2030	PERCENT CHANGE 1960-1970	PERCENT CHANGE 1970-1980
Atkinson	1,017	2,291	3,394	5,082	6,290	7,490	8,460	9,377	10,386	125.3	121.8
Barrington	1,036	1,865	3,518	4,473	5,921	7,684	9,774	12,186	14,891	80.0	139.8
Brentwood	1,072	1,468	1,822	2,012	2,545	3,097	3,581	4,073	4,732	36.9	37.1
Brookfield	145	198	345	431	571	741	942	1,175	1,435	36.5	117.7
Candia	1,490	1,997	2,549	2,615	3,237	3,854	4,354	4,825	5,345	34.0	30.9
Chester	1,053	1,382	1,910	2,800	3,471	4,140	4,684	5,202	5,783	31.2	102.6
Danville	605	924	1,222	1,486	1,839	2,190	2,473	2,741	3,037	52.7	60.8
Deerfield	714	1,178	1,717	2,657	3,521	4,572	5,815	7,251	8,875	64.9	125.6
Dover	19,131	20,850	22,376	22,014	25,354	29,526	32,624	35,283	39,012	9.0	5.6
Durham*	5,504	8,869	9,248	12,706	14,092	16,655	18,923	20,061	22,688	61.1	43.3
East Kingston	574	838	1,046	1,003	1,242	1,478	1,670	1,851	2,050	46.0	19.7
Epping	2,006	2,356	2,701	3,174	3,936	4,697	5,316	5,908	6,575	17.4	34.7
Exeter	7,243	8,892	10,429	11,395	14,112	16,814	19,005	21,082	23,386	22.8	28.1
Farmington	3,287	3,588	4,068	3,762	4,357	5,069	5,592	6,055	6,686	9.1	4.9
Fremont	783	993	1,269	1,719	2,134	2,548	2,888	3,213	3,584	26.8	42.2
Greenland	1,196	1,784	2,000	1,767	2,187	2,605	2,942	3,261	3,612	49.2	-1.0
Hampstead	1,261	2,401	3,365	5,141	6,369	7,590	8,581	9,522	10,569	90.4	114.1
Hampton	5,379	8,011	9,717	10,098	12,514	14,919	16,874	18,733	20,811	48.9	26.1
Hampton Falls	885	1,254	1,415	1,750	2,177	2,605	2,959	3,301	3,700	41.7	39.6
Hudson	5,876	10,638	12,595	13,378	15,008	16,109	17,241	18,257	19,353	81.0	25.8
Kensington	708	1,044	1,251	1,145	1,481	1,763	1,992	2,208	2,445	47.5	9.7
Kingston	1,672	2,882	3,803	4,233	4,993	5,948	6,721	7,453	8,262	72.4	46.9
Lee	931	1,481	1,748	1,791	2,118	2,464	2,718	2,944	3,250	59.1	20.9
Madbury	556	704	866	952	1,103	1,283	1,415	1,532	1,692	26.6	35.2
Middleton	349	430	482	606	803	1,042	1,251	1,354	1,495	23.2	40.9
Milton	1,418	1,859	2,356	2,222	2,742	3,200	3,551	3,829	4,248	31.1	19.5
New Castle	823	975	954	1,105	1,319	1,554	1,744	1,922	2,117	18.5	13.3
Newfields	737	843	813	1,090	1,350	1,607	1,815	2,012	2,228	14.4	29.3
Newington	1,045	798	614	771	960	1,151	1,309	1,462	1,644	-23.6	-3.4

TABLE 6 (continued)

COMMUNITY	1960	1970	1977	1980	1990	2000	2010	2020	2030	PERCENT CHANGE 1960-1970	PERCENT CHANGE 1970-1980
Newmarket	3,153	3,361	3,661	3,764	4,668	5,571	6,307	7,010	7,805	6.6	12.0
Newton	1,419	1,920	2,895	3,400	4,209	5,015	5,667	6,285	6,969	35.3	77.1
North Hampton	1,910	3,259	3,504	3,730	4,624	5,516	6,242	6,934	7,712	70.6	14.5
Northwood	1,034	1,526	1,971	2,514	3,112	3,706	4,186	4,641	5,143	47.6	64.7
Nottingham	623	925	1,578	1,722	2,282	2,963	3,769	4,699	5,750	48.5	86.2
Pelham	2,605	5,408	8,069	8,117	9,767	10,483	11,220	11,881	12,595	107.6	50.1
Plaistow	2,915	4,172	5,589	5,487	6,791	8,086	9,133	10,123	11,213	61.6	16.4
Portsmouth**	25,833	25,727	28,517	24,050	29,300	34,735	39,122	43,262	47,807	-0.4	-6.5
Raymond	1,867	3,003	4,614	6,425	7,956	9,479	10,712	11,881	13,176	60.8	114.0
Rochester	15,927	17,928	19,979	20,937	24,177	28,143	31,071	33,623	37,153	12.6	16.7
Rollinsford	1,935	2,273	2,073	2,625	3,040	3,537	3,902	4,225	4,665	17.5	15.5
Rye	3,244	4,083	4,460	4,701	5,831	6,958	7,877	8,754	9,746	25.9	16.1
Salem	9,210	20,142	25,455	26,706	33,062	39,378	44,490	49,329	54,674	118.7	32.6
Sandown	366	741	1,596	2,055	2,722	3,533	4,493	5,602	6,850	102.5	177.3
Seabrook	2,209	3,053	5,331	7,586	9,391	11,185	12,363	14,010	15,527	38.2	148.5
Somersworth	8,529	9,026	10,174	9,618	11,126	12,948	14,287	15,467	17,082	5.8	6.6
South Hampton	443	558	694	615	762	907	1,025	1,136	1,258	25.9	10.2
Strafford	722	965	1,417	1,176	1,557	2,021	2,321	2,513	2,775	33.6	21.9
Stratham	1,033	1,512	2,022	3,012	3,987	4,886	5,519	6,118	6,776	46.4	99.2
Wakefield	1,223	1,420	2,358	2,341	2,671	2,938	3,064	3,356	3,619	16.1	64.9
Windham	1,317	3,008	4,720	6,319	7,838	9,354	10,591	11,772	13,108	128.4	110.1
TOTALS	<u>156,013</u>	<u>207,343</u>	<u>250,270</u>	<u>270,574</u>	<u>326,937</u>	<u>386,114</u>	<u>435,270</u>	<u>481,156</u>	<u>535,854</u>	<u>32.9</u>	<u>30.5</u>

NOTES: \* Includes dormitory residents at University of New Hampshire.  
 \*\* Includes population of Pease Air Force Base.

TOTAL STATE 709,264 877,592

The most important industrial area in terms of number of employers will continue to be one centering in Portsmouth, even after the year 2020. Although others will grow at will, the Portsmouth area will expand even more. It possesses natural and manmade attributes which give it a commanding edge over the rest of the region. It now has a deep water ocean port and it is expected that it may have a major commercial facility if civilian use of Pease Air Force Base becomes a reality.

A Second major industrial area is planned by 2020 for Seabrook, and a small part of Hampton Falls adjacent to it. The primary attraction for development in the study area will be the enormous amount of electric power available from the Seabrook Nuclear Power Plant, which is currently under construction. Another industrial area to the west of I-95 is also envisioned where the beginnings of a significant industrial area are already evident. The area has the advantage of good highway transportation to the north and south, and by 1990 to the west as well.

The third industrial area will extend along Route 101 from Exeter to Route 125 in Epping. It will not expand significantly until well after the Seabrook site, since it will suffer from its comparatively inadequate transportation facilities until completion of the Hampton-Manchester expressway, and an eventual reconstruction of Routes 125 and 108. Another industrial area in Epping at the intersection of Routes 125 and 101 is assumed to expand slowly over time and will merge with the Exeter Brentwood area.

Strafford-Rockingham Regional Council's plans situate oceanfront commercial recreation in Hampton. Like industry and commerce, the plan recognizes that commercial recreation already exists in scattered locations and in other areas and should continue to so exist, but recommends that the only concentration of commercial recreation to be greatly expanded is Hampton Beach.

It should be noted that much of this commercial activity is designed to serve residents of areas other than this region, predominantly tourists visiting the coast, along with transients heading to and from Maine and the maritime provinces of Canada. A much higher percentage of land is therefore devoted to commercial use than would be the case in a region with less impact from tourism.

Finally, the plan proposes two major commercial areas of regional importance. One is Portsmouth which is already significantly underway, and the second is expected to be around Exeter-Stratham. Outside of the Strafford-Rockingham Regional Council's jurisdiction, the Hudson/Pelham area may anticipate intense urban development. No major development is expected within the remaining six study area communities, including Candia, Chester, Deerfield, Raymond, Brookfield and Wakefield. Increases in residential acreage would be needed to accommodate the projected population growth and would appear in the construction of single family units. The continuing expansion of suburban-type growth is expected throughout the region.

## C. Description of Existing Problems

### 1. Overview

The following paragraphs describe problems and needs currently existing within the region that have been examined in this study. The problems have been identified during discussion with Federal, State and regional planning agency officials, from data developed for the Southeast New Hampshire Water Supply Study, from a preliminary planning overview done with the State, and from public workshops conducted as part of the study's public involvement program.

The major problems here concern water supply and water quality. The main focus of this water resources study will be on water supply. Water quality studies are being handled under the provisions of Section 208 of PL 92-500, the Clean Water Act. In southeastern New Hampshire two regional planning agencies, the Strafford-Rockingham Regional Council and the Lakes Region Planning Commission, have been designated by EPA to conduct 208 planning within their jurisdiction. Strafford-Rockingham Regional Council's designated 208 area is only that part of its region covered by the Southern Rockingham Regional District Commission. The remainder of 208 planning in southeastern New Hampshire is being done by the State through the Water Supply and Pollution Control Commission. Results of the 208 program will be evaluated and incorporated into our study where applicable. This should produce a more comprehensive water resource plan.

The other water resource components addressed in the study are flood damage reduction, navigation and recreation.

### 2. Water Supply

Of the 50 municipalities within the southeastern New Hampshire study area 23 are now served, at least in part, by municipal water systems. With the population explosion that is expected to continue here, many of the 27 communities not served will have to initiate a public water supply system within the study's time frame.

Average daily demand on the public water systems in 1977 was 17 million gallons per day (mgd). The current safe yield of the system is 33 mgd. By the year 2030 the SENH area is expected to have a net deficit of 20 mgd. These figures are misleading, however, in that they represent the region as a whole and do not reflect the varying conditions within the individual communities. In order to develop comprehensive water supply alternatives the present capabilities and future requirements of each community were evaluated. Subregional alternatives were formulated so that each community can develop in such a way that the region's water resources will be utilized to their full extent.

Estimates indicate about an overall water supply deficit of 7 mgd as early as 2000 for the study area. The 2030 demands and deficits of each community in the study area are listed in Table 7.

TABLE 7

PROJECTED DEMANDS AND DEFICITS FOR THE STUDY AREA  
(Communities with Public Supply Systems)

COMMUNITY	1980		1990				2000				2010				2020				2030						
	EXISTING	DEMANDS	DEFICITS																						
	SAFE YIELD (mgd)	AVG DAY	MAX DAY																						
Dover	3.20	2.52	5.42	0	2.22	2.99	6.88	0	3.68	3.62	7.42	0.42	4.22	4.16	7.90	0.96	4.70	4.67	8.41	1.47	5.21	5.43	9.77	2.23	6.57
Durham	1.70	0.87	2.00	0	0.30	1.00	2.30	0	0.60	1.25	2.83	0	1.13	1.51	3.31	0	1.61	1.59	3.50	0	1.80	2.41	5.06	0.71	3.37
Epping	0.14	0.13	0.38	0	0.24	0.17	0.48	0.03	0.34	0.22	0.62	0.08	0.48	0.26	0.70	0.12	0.56	0.30	0.84	0.16	0.70	0.35	0.91	0.21	0.77
Exeter	2.75	1.08	2.46	0	0	1.40	3.15	0	0.40	1.75	3.89	0	1.14	2.08	4.37	0	1.62	2.41	4.94	0	2.19	2.78	5.56	0	0.63
Farmington	1.44	0.32	0.83	0	0	0.36	0.94	0	0	0.43	0.97	0	0	0.48	1.20	0	0	0.54	1.35	0	0	0.61	1.46	0	0.02
Greenland w/Portsmouth	(0.18)	(0.50)	-	-	-	(0.23)	(0.62)	-	-	(0.29)	(0.75)	-	-	(0.34)	(0.88)	-	-	(0.40)	(1.00)	-	-	(0.46)	(1.15)	-	-
Hampton	3.73	1.25	4.79	0	1.06	1.64	5.67	0	1.94	2.05	6.65	0	2.92	2.44	7.54	0	3.81	2.83	8.42	0	4.69	3.29	9.60	0	5.87
Hudson	1.75	0.56	1.34	0	0	0.68	1.63	0	0	0.78	1.79	0	0.04	0.90	2.07	0	0.32	1.02	2.30	0	0.55	1.15	2.53	0	0.78
Milton	0.36	0.07	0.21	0	0	0.09	0.27	0	0	0.12	0.35	0	0	0.14	0.41	0	0.05	0.16	0.45	0	0.09	0.10	0.53	0	0.17
New Castle w/Portsmouth	(0.07)	(0.21)	-	-	-	(0.09)	(0.27)	-	-	(0.11)	(0.35)	-	-	(0.13)	(0.38)	-	-	(0.16)	(0.45)	-	-	(0.18)	(0.50)	-	-
Newfields	0.14	0.09	0.27	0	0.13	0.12	0.35	0	0.21	0.16	0.46	0.02	0.32	0.18	0.49	0.04	0.35	0.21	0.57	0.07	0.43	0.25	0.68	0.11	0.54
Newington w/Portsmouth	(0.13)	(0.38)	-	-	-	(0.16)	(0.45)	-	-	(0.20)	(0.55)	-	-	(0.23)	(0.62)	-	-	(0.27)	(0.72)	-	-	(0.31)	(0.81)	-	-
Newmarket	1.50	0.34	0.88	0	0	0.44	1.10	0	0	0.55	1.43	0	0	0.65	1.56	0	0.06	0.75	1.76	0	0.26	0.87	2.01	0	0.51
N. Hampton w/Portsmouth	(0.16)	(0.45)	-	-	-	(0.22)	(0.59)	-	-	(0.28)	(0.73)	-	-	(0.34)	(0.88)	-	-	(0.40)	(1.00)	-	-	(0.48)	(1.20)	-	-
Portsmouth	5.99	3.20	6.46	0	0.47	3.94	7.76	0	1.77	4.78	9.08	0	3.09	5.58	10.04	0	4.05	6.38	10.93	0.39	4.94	7.27	12.51	1.28	6.52
Raymond	0.18	0.29	0.81	0.11	0.63	0.39	1.01	0.21	0.83	0.50	1.25	0.32	1.07	0.61	1.46	0.43	1.28	0.72	1.73	0.54	1.55	0.85	2.00	0.67	1.82
Rochester	4.00	2.61	5.22	0	1.22	3.10	6.08	0	2.08	3.73	7.09	0	3.09	4.05	7.70	0.05	3.70	4.77	8.87	0.77	4.87	5.43	9.88	1.43	5.88
Rollinsford	0.18	0.13	0.38	0	0.20	0.16	0.45	0	0.27	0.20	0.55	0.02	0.37	0.24	0.65	0.06	0.47	0.27	0.72	0.09	0.54	0.32	0.83	0.14	0.65
Rye w/Hampton	(0.13)	(0.38)	-	-	-	(0.17)	(0.57)	-	-	(0.21)	(0.68)	-	-	(0.25)	(0.75)	-	-	(0.29)	(0.86)	-	-	(0.34)	(0.99)	-	-
Rye w/Portsmouth	(0.15)	(0.43)	-	-	-	(0.21)	(0.68)	-	-	(0.28)	(0.73)	-	-	(0.34)	(0.88)	-	-	(0.41)	(1.03)	-	-	(0.49)	(1.23)	-	-
Salem	1.80	1.73	3.88	0	2.08	2.28	5.15	0.48	3.35	2.91	5.82	1.11	4.02	3.49	6.81	1.69	5.01	4.05	7.90	2.25	6.10	4.79	9.10	2.99	7.30
Seabrook	1.77	0.92	2.12	0	0.35	1.17	2.57	0	0.80	1.43	3.12	0	1.35	1.67	3.54	0	1.77	1.93	4.05	0.16	2.28	2.20	4.51	0.43	2.74
Somersworth	1.93	1.07	2.36	0	0.42	1.25	2.72	0	0.79	1.55	3.30	0	1.37	1.70	3.59	0	1.66	1.90	3.89	0	1.96	2.14	4.28	0.21	2.35
Wakefield	0.25	0.16	0.46	0	0.21	0.19	0.53	0	0.28	0.22	0.62	0	0.37	0.24	0.64	0	0.39	0.27	0.71	0.02	0.46	0.30	0.81	0.05	0.56
SUB TOTAL	32.81	17.34	40.27	0.11	9.53	21.37	49.04	0.72	17.34	26.25	57.24	1.97	24.98	30.38	63.98	3.35	31.41	34.77	71.34	5.92	38.62	40.63	82.02	10.46	47.05

TABLE 7 (continued)

PROJECTED DEMANDS AND DEFICITS FOR THE STUDY AREA																									
(Communities Without Public Supply Systems)																									
COMMUNITY	EXISTING SAFE YIELD (mgd)	1980				1990				2000				2010				2020				2030			
		DEMANDS AVG DAY	DEMANDS MAX DAY	DEFICITS AVG DAY	DEFICITS MAX DAY																				
Atkinson	0	0.25	0.68	0.25	0.68	0.34	0.88	0.34	0.88	0.44	1.10	0.44	1.10	0.53	1.30	0.53	1.30	0.62	1.49	0.62	1.49	0.73	1.68	0.73	1.68
Barrington	0	0.18	0.50	0.18	0.50	0.26	0.70	0.26	0.70	0.37	0.93	0.37	0.93	0.50	1.25	0.50	1.25	0.66	1.58	0.66	1.58	0.86	1.98	0.86	1.98
Brentwood	0	0	0	0	0	0.12	0.35	0.12	0.35	0.16	0.45	0.16	0.45	0.19	0.53	0.19	0.53	0.23	0.62	0.23	0.62	0.29	0.75	0.29	0.75
Brookfield	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candia	0	0.10	0.30	0.10	0.30	0.13	0.38	0.13	0.38	0.17	0.48	0.17	0.48	0.21	0.57	0.21	0.57	0.24	0.65	0.24	0.65	0.29	0.76	0.29	0.76
Chester	0	0	0	0	0	0.14	0.41	0.14	0.41	0.18	0.50	0.18	0.50	0.22	0.59	0.22	0.59	0.26	0.69	0.26	0.69	0.30	0.78	0.30	0.78
Danville	0	0	0	0	0	0	0	0	0	0.11	0.32	0.11	0.32	0.13	0.38	0.13	0.38	0.15	0.43	0.15	0.43	0.18	0.50	0.18	0.50
Deerfield	0	0.10	0.30	0.10	0.30	0.14	0.41	0.14	0.41	0.20	0.55	0.20	0.55	0.27	0.72	0.27	0.72	0.36	0.92	0.36	0.92	0.47	1.18	0.47	1.18
E. Kingston	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10	0.30	0.10	0.30	0.12	0.35	0.12	0.35
Fremont	0	0	0	0	0	0	0	0	0	0.12	0.35	0.12	0.35	0.15	0.43	0.15	0.43	0.17	0.48	0.17	0.48	0.21	0.57	0.21	0.57
Hampstead	0	0.24	0.65	0.24	0.65	0.32	0.83	0.32	0.83	0.41	1.03	0.41	1.03	0.50	1.25	0.50	1.25	0.59	1.42	0.59	1.42	0.69	1.66	0.69	1.66
Hampton Falls	0	0	0	0	0	0.10	0.30	0.10	0.30	0.13	0.38	0.13	0.38	0.16	0.45	0.16	0.45	0.19	0.53	0.19	0.53	0.23	0.62	0.23	0.62
Kensington	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10	0.30	0.10	0.30	0.12	0.35	0.12	0.35	0.14	0.41	0.14	0.41
Kingston	0	0.18	0.50	0.18	0.50	0.23	0.62	0.23	0.62	0.30	0.78	0.30	0.78	0.36	0.92	0.36	0.92	0.43	1.08	0.43	1.08	0.51	1.26	0.51	1.26
Lee	0	0	0	0	0	0	0	0	0	0.11	0.32	0.11	0.32	0.13	0.38	0.13	0.38	0.15	0.43	0.15	0.43	0.17	0.48	0.17	0.48
Madbury	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Middleton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Newton	0	0.17	0.48	0.17	0.48	0.22	0.59	0.22	0.59	0.29	0.75	0.29	0.75	0.35	0.91	0.35	0.91	0.41	1.03	0.41	1.03	0.49	1.22	0.49	1.22
Northwood	0	0	0	0	0	0.12	0.35	0.12	0.35	0.16	0.45	0.16	0.45	0.19	0.53	0.19	0.53	0.23	0.62	0.23	0.62	0.27	0.72	0.27	0.72
Nottingham	0	0	0	0	0	0	0	0	0	0.12	0.35	0.12	0.35	0.16	0.45	0.16	0.45	0.21	0.57	0.21	0.57	0.27	0.72	0.27	0.72
Pelham	0	0.35	0.91	0.35	0.91	0.46	1.15	0.46	1.15	0.53	1.27	0.53	1.27	0.60	1.44	0.60	1.44	0.69	1.66	0.69	1.66	0.77	1.79	0.77	1.79
Plaistow	0	0.27	0.72	0.27	0.72	0.36	0.91	0.36	0.91	0.46	1.15	0.46	1.15	0.55	1.35	0.55	1.35	0.66	1.58	0.66	1.58	0.77	1.79	0.77	1.79
Sandown	0	0	0	0	0	0.12	0.35	0.12	0.35	0.17	0.48	0.17	0.48	0.23	0.62	0.23	0.62	0.31	0.81	0.31	0.81	0.40	1.02	0.40	1.02
South Hampton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strafford	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10	0.30	0.10	0.30	0.11	0.32	0.11	0.32	0.13	0.38	0.13	0.38
Stratham	0	0.13	0.38	0.13	0.38	0.19	0.53	0.19	0.53	0.25	0.68	0.25	0.68	0.30	0.78	0.30	0.78	0.35	0.91	0.35	0.91	0.41	1.04	0.41	1.04
Windham	0	0.27	0.72	0.27	0.72	0.36	0.91	0.36	0.91	0.46	1.15	0.46	1.15	0.56	1.34	0.56	1.34	0.67	1.61	0.67	1.61	0.79	1.82	0.79	1.82
SUB TOTAL	0	2.24	6.14	2.24	6.14	3.61	9.67	3.61	9.67	5.14	13.47	5.14	13.47	6.49	16.79	6.49	16.79	7.91	20.08	7.91	20.08	9.49	23.48	9.49	23.48
GRAND TOTAL	32.81	19.58	46.41	2.35	15.67	24.98	58.71	4.33	27.01	31.39	70.71	7.11	38.45	36.87	80.77	9.84	48.20	42.68	91.42	13.83	58.70	50.12	105.51	19.95	70.53

The four largest communities, Portsmouth, Dover, Exeter and Salem account for 40 percent of the study area's population and 45 percent of the publicly supplied water. With the exception of Exeter these larger communities can barely meet present needs.

The city of Portsmouth's water supply system is the largest in the SENH area. It serves the developed part of the city as well as portions of Newington, Greenland, Rye and New Castle. Its main source of water is the Bellamy Reservoir in Madbury. A series of wells, together with the reservoir, provide a total supply of 6.0 mgd. The existing average day demand on the study is 3.2 and it is expected to reach 7 mgd by 2030.

Salem, the second largest community in the study area, has an immediate need of additional water supplies. The town's population more than doubled in the past 20 years. Projections based on 1971 data had indicated an average day deficit of 0.38 mgd by 1980 but the lack of adequate water supply has had a dampening effect on current per capita consumption, decreasing it from 75.1 gpcd in 1971 to 66.4 gpcd in 1980. Therefore, the latest 1980 projections do not reflect the actual water supply needs of the community. The 1.8 mgd capacity of Canobie Lake, Salem's water supply, is not expected to meet the communities short-term needs.

Epping and Raymond face a situation similar to that of Salem's although not of the same magnitude. They will be unable to meet their average daily demands as early as 1980. Their municipal wells yield .14 and .18 mgd respectively, and by 1980 the two towns will have combined deficit of approximately .1 mgd. Epping added a second well in an attempt to augment its supply, but the well subsequently failed. Earlier investigations have indicated there is a potential groundwater source in Epping that is capable of supplying all future demands.

The community of Dover will require more water by 2000 if the population growth there continues its current trend. The average day demand of 2.5 mgd is expected to reach 3.6 mgd by 2000. Its water supply system, which consists of a number of gravel packed wells, has a combined safe yield of 3.2 mgd. This system also serves a very small part of Rollinsford and Madbury. During the summer of 1977 the daily demand became great enough to require a ban on water for the first time in 18 years.

Seabrook is able to meet its projected average day demand through 2010 and Hampton through 2000 with their current water supply systems. By 1980, however, neither community will be able to meet maximum day demands. They both experience a large influx of summer visitors who place heavy daily demands on the systems. Unless additional supplies are developed, the combined maximum day deficit for the two communities will be about 2.0 mgd in 1980. North Hampton and part of Rye are also served by Hampton's municipal water system.

Durham has a municipal surface supply of 1.7 mgd, two-thirds of which is used by the University of New Hampshire. Average day demand, now .87 mgd, is projected to reach 2.4 mgd by 2030.

Newfields, a small community of approximately 800 residents, has an average day demand of 0.9 mgd. Its municipal well system has a safe yield of .14 mgd; however, the average day demand is projected to reach .18 mgd by 2010.

The neighboring communities of Rochester, Somersworth and Rollinsford all have a similar water supply situation -- namely, municipal water supplies capable of meeting only short range needs. Rochester, largest of the three communities, has a surface water supply system with a safe yield of 4.0 mgd. Its average day demand is expected to be 5.4 mgd by 2030. Somersworth has a combined surface and groundwater supply system with a safe yield of 1.93 mgd. With this present system Somersworth will need additional water by the year 2030. Additional supplies are available in Somersworth, but their development would require expansion of the existing treatment plant. By 2000 the average day demand for Rollinsford will exceed the safe yield of existing wells.

Exeter's water supply system can meet its projected average day demands throughout the time frame of the study. However, treatment facilities will have to be expanded to meet maximum day demands beyond 1990 because the present supply is limited by a 2.4 mgd capacity water treatment plant. Total safe yield of the municipal system is 2.75 mgd since a .35 mgd well not requiring treatment also feeds the system. With expansion of the treatment plant to its maximum design capacity of 4.0 mgd, Exeter would have enough water to meet all of its projected maximum day demands through 2030. In addition to Exeter, the communities of Milton, Newmarket, Farmington, Hudson and Wakefield have sufficient water supplies to meet their projected long range demands.

### 3. Water Quality

The water quality of the many lakes and rivers in the SENH area is classified according to the standards in Table 8. The majority of the lakes in New Hampshire are classified as B or higher quality and are acceptable for both fishing and swimming.

All of the rivers in the State are required by statute to meet the goal of "fishable-swimmable" (Class B) water by 1983. None of the major streams in the study area now conform throughout their entire length to the legal classification. Several segments are currently graded at D or lower. In general, the Class D segments are found in the Exeter (Squamscott), Bellamy, Cocheco, Salmon Falls, Oyster and Lamprey Rivers. These and the other rivers in the study area also contain sections ranging between Class B and Class C.

Both point and nonpoint sources of pollution are responsible for the downgrading of the area's waters. Point sources of pollution include industrial discharges, direct discharge of domestic sewage by the towns and failure of ground disposal systems. In the past, failures have occurred in Raymond, Newfields, Newington, Greenland and Epping.

TABLE 8

WATER QUALITY STANDARDS

	Class A <sup>2</sup>	Class B <sup>2</sup>	Class C <sup>2</sup>	Class D <sup>2</sup>
	Potentially acceptable for public water supply after disinfection. No discharge of sewage or other wastes. (Quality uniformly excellent.)	Acceptable for bathing and recreation, fish habitat and public water supply after adequate treatment. No disposal of sewage or wastes unless adequately treated. (High aesthetic value.)	Acceptable for recreational boating, fishing and industrial water supply with or without treatment, depending on individual requirements. (Third highest quality.)	Aesthetically acceptable. Suitable for certain industrial purposes, power and navigation.
Dissolved Oxygen	Not less than 75% Sat.	Not less than 75% Sat.	Not less than 5 p.p.m.	Not less than 2 p.p.m.
Coliform Bacteria per 100 ml	Not more than 50	Not more than 240 in fresh water. Not more than 70 MPN in salt or brackish water.	Not specified	Not specified
pH	Natural	6.5 - 8.0	6.0 - 8.5	Not specified
Substances potentially toxic	None	Not in toxic concentrations or combinations.	Not in toxic concentrations or combinations.	Not in toxic concentrations or combinations.
Sludge deposits	None	Not objectionable kinds or amounts.	Not objectionable kinds or amounts.	Not objectionable kinds or amounts.
Oil and Grease	None	None	Not objectionable kinds or amounts.	Not of unreasonable kind, quantity or duration.
Color	Not to exceed 15 units.	Not in objectionable amounts.	Not in objectionable amounts.	Not of unreasonable kind, quantity or duration.
Turbidity	Not to exceed 5 units.	Not to exceed 10 units in trout water. Not to exceed 25 units in non-trout water.	Not to exceed 10 units in trout water. Not to exceed 25 units in non-trout water.	Not of unreasonable kind, quantity or duration.
Slick, Odors and Surface-Floating Solids	None	None	Not an objectionable kinds or amounts.	Not of unreasonable kind, quantity or duration.
Temperature	No artificial rise	NHFGD, NEIWPCC, or NTAC-DI -- whichever provides most effective control. <sup>3</sup>	NHFGD, NEIWPCC or NTAC-DI -- whichever provides most effective control. <sup>3</sup>	Shall not exceed 90°F.

## NOTE:

<sup>1</sup>As of January 1, 1970, Based on Chapter 149 Revised Statutes, New Hampshire Water Supply and Pollution Control Commission.

<sup>2</sup>The waters in each classification shall satisfy all provisions of all lower classifications. For complete details see Chapter 149 RSA.

<sup>3</sup>NHFGD -- New Hampshire Fish and Game Department

NEIWPCC -- New England Interstate Water Pollution Control Commission

NTAC-DI -- National Technical Advisory Committee, Department of the Interior

Combined sanitary and stormwater sewerage systems pose a major threat to water quality during heavy storms because the sudden addition of a large volume of water will overtax their handling capabilities. The usual solution for dealing with this increased flow is diversion of the combined storm runoff and raw sewage directly into the receiving body of water. The towns with combined or partially combined sewerage systems are Milton, Somersworth, Dover, Exeter and Portsmouth.

Nonpoint pollution usually results from agriculture, forestry, mining and urban runoff as well as urban and rural construction. All are present in New Hampshire.

Agricultural pollution is generally associated with fertilizers, sediment from erosion and pesticides. These pollutants, for the most part, are carried by surface runoff. High coliform counts in Mallego Brook in Madbury and the Piscassic River in Newfields have been ascribed to runoff carrying the droppings of grazing livestock.

Regional sand and gravel operations are another source of nonpoint source pollution. The pollutants are silt and clay, which cause turbidity and color in the streams.

Sediment carried by runoff water to streams and surface water is the major pollutant resulting from forestry activities. Poor forest management and careless logging operations cause most of this problem.

Although surface waters have suffered from these practices, groundwater quality in the study area is good. It is generally pleasing in appearance with most of it clear and colorless and containing very little suspended matter. Analyses show that chemical constituents and properties of groundwater are usually well under or within accepted health limits. Some chemical analyses of groundwater in sand and gravel aquifers in southeastern New Hampshire follow (EPA-1974):

<u>NUMBER OF SAMPLES</u>	<u>CONSTITUENT OR PROPERTY</u>	<u>MEAN VALUE (concentration in mg/l)</u>
30	Iron (Fe)	00.035
52	Chloride (Cl)	09.500
24	Sulfate (SO <sub>4</sub> )	12.500
35	Hardness (as Ca CO <sub>3</sub> )	43.000
24	Total dissolved solids	78.500
52	pH	06.800

They show the water to be free from contaminants, low in dissolved solids and soft (less than 60 mg/l of hardness).

While overall groundwater quality is very good, there are local problems. Iron and manganese may occur in concentrations greater than EPA's recommended limits for drinking water -- 0.3 and 0.05 mg/l, respectively. There have been cases recorded of wells being forced to shut down because of high concentrations of iron and manganese. The water is weakly acidic with a pH of less than 7.0, and problems with corrosion of metal plumbing systems have occurred.

Urbanization has also affected groundwater quality in some localities. Degradation of water may occur near sanitary landfills, major highways, large clusters of septic tanks and croplands. Nearby polluted surface waters can contaminate groundwater through induced infiltration.

#### 4. Flood Damage Reduction

Flooding can damage and destroy property, displace families, create serious health hazards, disrupt business communications and most seriously, cause loss of life. Increased development on flood plains will intensify potential for these damages.

There is one existing major Federally constructed flood control project in the study area, a local protection project in Farmington consisting of a river channel improvement, dikes and a floodwall along more than two miles of the Cocheco River. In addition, there are two shoreline protection projects, one at Hampton Beach and the other at Wallis Sands State Beach. These two projects consisted of beach restoration and construction of protective groins.

The problem of flood control has been addressed under several authorities in the North Atlantic Regional Water Resources Study (NAR) and the New England-New York Inter-Agency Committee Report (NENYIAC).

Thirty-four of the communities in the SENH study area are being investigated in the Department of Housing and Urban Development's (HUD) Federal Flood Insurance Administration Program (FIA). Of this total six are in the regular program and the remaining twenty-nine are in the emergency program.

FIA flood hazard boundary maps delineating the 100-year flood plain have been prepared for thirteen additional communities in the study area not in the FIA program. Flood Plain Information Reports will be examined to determine if there are any areas with significant potential for flood losses. If such areas are identified, alternatives will be developed to reduce the potential for loss.

The study area is subject to two distinctly different types of flooding, riverine and coastal. However, flooding was not among the subjects brought up for discussion at the three public workshop meetings held in September 1978.

Based on information gathered to date, the study area does not have a history of severe flooding so study efforts in the area of flood damage reduction were minimal.

## 5. Navigation

Portsmouth Harbor is the only major port serving commercial traffic in the study area. In 1975 nearly 3 million tons of waterborne cargo passed through this port. There is also small craft pleasure boating on the Exeter and Lamprey Rivers, Great and Little Bays and Little Rye and Hampton Harbors. Dredging of some existing channels and widening of turning basins in some of the waterways might be necessary to better open the area to small boat traffic.

Periodic maintenance dredging of Portsmouth Harbor will be done as the need arises. A feasibility study for improving the existing 35-foot Piscataqua River-Portsmouth Harbor channel by widening at the bends and increasing the areas of the turning basins is being conducted by the Corps of Engineers.

Town officials of Exeter requested the Corps look into the possibility of redredging the Federal channel in the Exeter River from the Ox Bow to the town of Exeter for the purpose of recreational boating. This issue will be addressed under the Corps maintenance program for existing Federal projects.

There were no additional navigation needs or problems identified during the reconnaissance phase.

## 6. Recreation

Southeastern New Hampshire offers a wide range of scenery: spectacular fall foliage, clean, sandy beaches, beautiful lakes and picturesque countryside. These qualities attract both residents and nonresidents. Many recreational activities, especially in the coastal area, involve such water-related pastimes as swimming, boating, canoeing and fishing.

All water bodies larger than 10 acres in New Hampshire are public property held in trust for public use. Public access to these bodies of water, however, is sometimes impeded because of private development along the shorelines.

The demand for water-related recreation facilities is increasing as the population of the SENH area increases. New recreational facilities of all types will be required to satisfy the public's needs and wishes.

The development of water-oriented recreational plans will not be a task of this study. The Statewide Comprehensive Outdoor Recreation Plans (SCORP) do an adequate job of this. Various regional planning agencies have also included recreation in their land use planning for their service areas. These plans address themselves to preservation of open space for recreation and protection of flood plains by using them as recreation areas. The SCORP plans have been examined and where appropriate recreation will be incorporated into water resource development plans. This multiple use will serve to optimize development of the resource.

#### D. Planning Objectives

Specific planning objectives for this study were developed as part of the Southeastern New Hampshire Reconnaissance Report, which was completed in May, 1979. The objectives were derived from an analysis of water and related land resources problems and needs identified through a series of public workshops and meetings with Federal, State, regional and local agency representatives and special interest groups. These objectives address the water supply, flood damage reduction, water quality, navigation and recreation needs of the study area.

##### 1. Water Supply

The objectives addressing water supply center around maintaining present supply and developing additional sources. The specific objectives are:

- . Contribute to the protection of existing surface water and groundwater resources to meet the short-term (2000) and long-term (2030) needs of the study area.

- . Contribute to the modification of present water demands within the study area to extend use of existing resources and to meet the short-term (2000) and long-term (2030) water needs.

- . Contribute to development of additional groundwater and surface water resources to meet the study area's projected short-term (2000) and long-term (2030) water supply deficits.

- . Contribute to the conservation and protection of wetlands, fish and wildlife resources and unique natural areas in the study area during the study time frame (1980-2030).

##### 2. Flood Damage Reduction

Flood damage reduction objectives focus on minimizing flood hazards and damages in the study area's floodplains. Specific objectives are:

- . Contribute to the reduction of the flood hazard and associated flood damages along the New Hampshire coastal area in the study time frame (1980-2030) and beyond.

- . Contribute to reduction of flood hazard and associated flood damages resulting from development on floodplains along the study area's rivers in the study time frame (1980-2030) and beyond.

### 3. Water Quality

Objectives for water quality focused on the enhancement of existing water quality conditions in the study area. Specific objectives are:

. Contribute to surface water quality for water supply, fishery and recreational purposes in the study area during the study time frame (1980-2030).

. Contribute to groundwater quality for water supply use in the study area during the study time frame (1980-2030).

### 4. Navigation

Objectives addressing navigation provided for widening and maintaining river channels to enhance recreational and commercial opportunities during the study time frame (1980-2030) and beyond. Specific objectives are:

. Contribute to preservation and maintenance of existing channels for the purpose of recreational and commercial boating in the study area during the study time frame (1980-2030) and beyond.

. Contribute to navigation for recreational purposes on the Exeter River in Exeter, New Hampshire.

### 5. Recreation

Objectives for recreation were directed toward development of additional recreational opportunities to meet the increase in recreational needs in the study area during the study time frame (1980-2030) and beyond. Specific objectives are:

. Contribute to recreational opportunities in development of water resources in the study area during the study time frame (1980-2030).

. Contribute to the preservation of water quality in the study area through discreet siting of recreational resources during the study time frame (1980-2030).

### 6. Summary

The primary objective being addressed by this study is water supply as it is the major water resource problem in Southeastern New Hampshire. Alternatives developed as part of this study will address all of the water supply objectives outlined earlier in this section. Water quality objectives outlined in this section focus on water quality concerns as they apply to water supply development. Other water quality problems are being handled by the State under provisions of Section 208 of PL 92-500, the Clean Water Act. Flood damage reduction objectives have been addressed

by the Office of State Planning and by various consultants through the Department of Housing and Urban Development's Federal Flood Insurance Administration Program. Objectives addressing navigation needs will not be addressed any further in this study as they come under the authority of the Corps maintenance program for existing Federal channels. As is the case with water quality, recreational objectives have been formulated around water supply development and will be addressed in this vein as the study progresses.

SECTION III

FORMULATION OF ALTERNATIVE PLANS

### III. FORMULATION OF ALTERNATIVE PLANS

Alternative measures were investigated to meet the planning objectives for water supply previously set forth. Alternative plans for future water supply have been evaluated to determine their feasibility with respect to their associated social, economic, environmental and institutional impacts. Public acceptance of the alternatives was another important criteria. This section describes all the alternatives which were investigated and the screening process that was applied.

#### A. Management Measures

Management measures which address the objective of maintaining present water supplies and developing additional sources for the study area fall into several general categories: surface water development, groundwater development, out of basin transfers or diversions, conservation, and desalination.

Other planning objectives which are inherently addressed in considering development of water resources for water supply are contributing to recreational opportunities and preservation/enhancement of water quality.

#### B. Plan Formulation Rationale

The plan formulation task involves the development of alternative water resource management systems, outlined in the previous section, that respond to identified problems and concerns in the study area as well as to the specific study planning objectives.

Alternatives for water supply were evaluated on their ability to meet the needs of the entire study area and not individual communities. Development of local supplies by themselves will not meet the future requirements of the entire study area. Several communities have already exhausted local resources and now require some type of "regional" solution. The need for some type of regional or subregional alternative for future supply has long been recognized by State and local planning officials; however, not all of the public is aware of this problem. A "home rule" approach has long governed development of water supply sources in Southeastern New Hampshire. Alternative plans developed during the course of this study have been economically evaluated as complete plans and not by individual components. The individual components of the alternatives were, however, evaluated against one another when more than one was available. Rationale for this evaluation is explained later when the individual plans are discussed.

Once all possible alternative plans had been formed they were evaluated to determine their economic feasibility. Those plans which were considered feasible were assessed on economic, environmental and social parameters. The following sections will detail the various alternative plans outlined, their evaluation and finally the trade-off comparison which led to the determination of plans warranting future investigation.

### C. Plans of Others

Some plans developed by Federal, State, regional and local governmental agencies address or affect in part the water supply planning objectives for this study. Plans have been developed for local communities which address the needs for future supply in that community. Also, the State has investigated subregional alternatives for parts of the study area. None of these plans meet the planning objectives for the entire study area. These plans developed by others were considered and incorporated where feasible in developing alternatives to meet the needs of the study area.

### D. Development of Alternative Plans

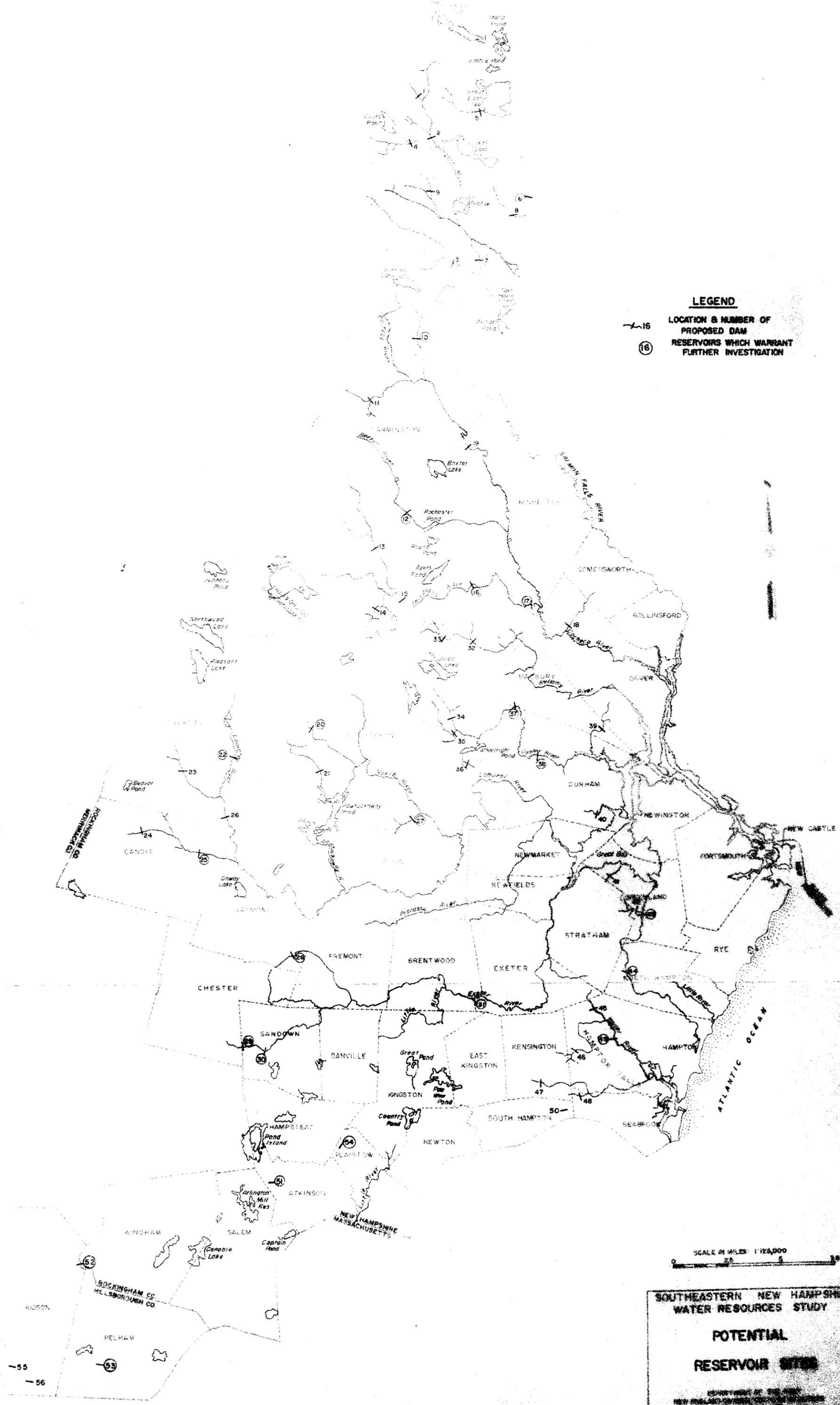
Management measures which address the planning objectives are presented in this section in more detail. Prior to development of alternatives which involve combinations of management measures individual measures, such as groundwater development, were evaluated on their ability to meet the future demands of the study area. Development of the individual measures will be discussed first and then development of those alternatives involving combination of management measures will be discussed.

1. Surface Water Development - The first step in locating future potential surface water supply sources was to identify all potential reservoir sites in the study as shown on Plate 2. Utilizing the criteria developed by the U.S. Department of Agriculture Soil Conservation Service (SCS) as part of the North Atlantic Regional Water Resources Study, Table 9, 56 potential reservoir sites were identified. Each site was visited to determine site characteristics, developments and general engineering, environmental, economic and social impacts.

The yield of each reservoir was obtained by computing the storage ratio of the particular reservoir in million gallons of volume per square mile of drainage area. The total water surface area of the drainage basin was then estimated. Reservoir volume, tributary drainage area and proposed reservoir water surface area were taken from the SCS data. Existing water surfaces were estimated from USGS quadrangle maps. The curves were entered with this data and unit yields were determined. Unit yields were then multiplied by the total tributary area to determine the dependable yield for the particular reservoir. Each reservoir site was developed to its maximum potential. Once the safe yields of the potential reservoir sites were determined the reservoirs were evaluated on their ability to meet the 2030 average day deficit. Those sites unable to meet 2030 deficits were considered infeasible to develop since an additional source would ultimately be required.

The next screening iteration was based on unit cost criteria. Unit costs were derived by dividing the estimated total construction cost by the safe yield. Reservoirs serving the same need areas were then grouped and evaluated based on their unit costs. Any site having a significantly higher unit cost in comparison to other sites serving the same need area was considered uneconomical and eliminated from the study. After completion of the unit cost screening, 29 potential reservoir sites remained to be evaluated as future water supply sources.

**LEGEND**  
 - 15 LOCATION & NUMBER OF PROPOSED DAM  
 (16) RESERVOIRS WHICH WARRANT FURTHER INVESTIGATION



SCALE IN MILES 1:125,000  
 0 2.5 5 7.5 10

**SOUTHEASTERN NEW HAMPSHIRE  
 WATER RESOURCES STUDY**  
**POTENTIAL  
 RESERVOIR SITES**  
 COURTESY OF THE NEW  
 HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES

-55  
 -56

TABLE 9

CRITERIA FOR RESERVOIR DEVELOPMENT

<u>PARAMETER</u>	<u>REQUIREMENT</u>
1. Drainage Area	$.5 \text{ mi}^2 < \text{D.A.} < 50 \text{ mi.}^2$
2. Ratio of Drainage Area to Area of Beneficial Pool	$\geq 10 \text{ to } 1$
3. Depth of Beneficial Pool	$\geq 7 \text{ feet}$
4. Area of Beneficial Pool	$\geq 10 \text{ acres}$
5. Capacity of Beneficial Pool	$\geq 100 \text{ acre-feet}$
6. Maximum Beneficial Pool Capacity-Storage Volume	$\leq 25 \text{ inches of runoff}$
7. Maximum Height of Dam	$\leq 100 \text{ feet}$
8. Development	No Major Development in the Area

The design and cost of reservoir development, which formed one basis of comparison, was developed through use of the MAPS (Methodology for Areawide Planning Studies) computer program. This program, discussed in Appendix A, was utilized because cost estimates can be produced on a compatible and reasonably accurate basis for a large number of alternatives.

Of the 29 reservoir sites remaining, 25 were assessed for preliminary environmental impacts, however, 51,52,53 and 54 were identified and evaluated at the end of the original assessment iteration. These four sites would have primarily the same service area and have been evaluated by cost analysis only, as previously described. A preliminary environmental assessment of these four sites will be conducted. The remaining 25 sites were assessed in terms of their environmental impacts also.

The 25 sites investigated were broken down into 8 groups, with each group representing alternative locations for an impoundment that would serve the same population (see Table 10). Consequently, sites were ranked only against other sites within the same group. Ranking was based solely on available general information. Site specific information will be gathered during the next stage of investigation when the number of sites has been reduced. Factors such as projected need and ability to meet demands without assistance, technical feasibility from an engineering viewpoint of constructing at a given site, distance to population served, economic justification and environmental acceptability will determine those sites for further study.

For the purpose of ranking the sites, each criteria was given equal weight. No attempt was made to assign relative values to the criteria since such a task might easily become subjective and can be difficult to defend. However, this "equal weight" approach also raised some problems. For example, one criteria was the availability of information from the New Hampshire Waterfowl Inventory. Any potential site in or near those areas addressed in the State's study or lack of it, did not reflect the quality of waterfowl habitat that may be present. Consequently, the lack of information on a particular site, regardless of actual conditions at that site implied it was less environmentally productive or desirable to maintain. On the other hand, inclusion of this criteria was considered desirable since many sites not only have available information but information that indicates these sites have an excellent waterfowl habitat value.

Likewise, the wetlands criteria also posed problems. Under the U.S. Fish and Wildlife Service Classification System any water regime would be classified as wetlands; this would include lakes, rivers, and periodically flooded lands. These systems are defined as wetlands by their water regime and soils, not by vegetation. But acknowledging the presence of these wetlands does not allow for any assumption as to their productivity, or provide information on the functions they may perform. It should also be noted that the equal weight criteria does not address the size of these wetlands. Consequently, extensive wetland areas are considered equal in value to those areas that until recently would not have been designated wetlands.

TABLE 10  
ENVIRONMENTAL ASSESSMENT OF RESERVOIR SITES

SITE #	N. H. WATERFOWL SURVEY INFORMATION	WETLANDS	FORESTS	PUBLIC LAND	RELOCATION OF BUILDINGS UTILITIES, CEMETARIES	HCRS PRELIMINARY RECREATION LIST	THREATENED & ENDANGERED SPECIES	RARE AND ENDANGERED SPECIES	NATIVE COLD WATER FISHERIES	STOCKED	ANADROMOUS FISH PRESENT	ANADROMOUS FISH POTENTIAL	ANADROMOUS FISH PLANNED	UNIQUE FEATURES	TOTAL +'s	SAFE YIELD (mgd)	RANK
2	-	+	+	-	+	-	-	-	+	-	-	-	-	-	4	3.3	1
5	-	+	+	-	+	-	-	-	+	-	-	-	-	-	4	1.8	2
6	+	+	+	-	+	-	+	-	-	+	-	-	-	+	6	15.9	1
7	+	+	+	-	+	-	+	-	-	+	-	-	-	-	7	6.7	3
10	-	+	+	-	+	-	-	-	+	-	-	-	+	-	7	8.9	2
12	+	+	+	-	+	-	-	+	+	-	-	-	-	-	5	4.6	1
15	-	+	+	-	+	-	-	+	+	-	-	-	-	-	9	36.8	3
16	+	+	+	-	+	-	-	+	+	-	-	-	-	-	7	18.9	2
17	+	+	+	-	+	-	-	+	+	-	-	-	-	-	9	18.3	4
19	-	+	+	-	+	-	-	+	+	-	-	-	+	-	9	18.1	5
20	-	+	+	-	+	-	-	+	+	-	-	-	-	-	4	2.5	1
21	+	+	+	+	+	-	-	+	+	-	-	-	-	-	6	4.2	2
22	-	+	+	-	+	-	-	+	+	-	-	-	-	-	8	5.0	4
25	+	+	+	-	+	-	-	+	+	-	-	-	-	-	7	5.3	3
26	-	+	+	-	+	-	-	+	+	-	-	-	-	+	9	9.8	5
27	+	+	+	-	+	-	-	+	+	-	-	-	+	+	10	3.9	1
28	+	+	+	-	+	-	-	+	+	-	-	-	-	-	9	18.3	3
29	-	+	+	-	+	-	-	+	+	-	-	-	-	+	9	3.5	4
30	-	+	+	-	+	-	-	+	+	-	-	-	-	+	6	2.6	1
31	-	+	+	-	+	-	-	+	+	-	-	-	-	+	9	42.2	2
37	-	+	+	+	+	-	-	+	+	-	-	-	-	-	10	3.9	1
38	-	+	+	+	+	-	-	+	+	-	-	-	-	+	11	7.4	2
43	-	+	+	+	+	-	-	+	+	-	-	-	-	+	10	5.5	1
44	+	+	+	-	+	-	-	+	+	-	-	-	-	+	10	2.4	2
49	+	+	+	-	+	-	-	+	+	-	-	-	-	+	11	3.4	3

The presence of both forested areas and public lands within impoundment sites is also noted where possible. Public lands found within potential sites included a State park and university research area.

Construction at many locations will require relocation of homes, barns, businesses, roads, section of railroad tracks, utility lines and cemeteries. The social impacts associated with such relocations will be addressed in detail during the next stage of study.

The Threatened and Endangered Species criteria applies to those species protected by Federal law. Only one specie, found in New Hampshire, the small whorled pogonia (*Isotria medeoloides*), falls into this category. Populations of this plant have been verified in Milton, New Hampshire as recently as summer of 1980. At present, it is fairly certain this plant is found within the boundaries of sites number 6,7, or 10. However, these three sites were still given a plus check mark to point out potential areas of concern. Actual field surveys may be required should one of these sites be carried into the final plans.

The Rare and Endangered Species criteria addresses those species not protected by Federal law and yet considered to have some value when found in the State (uniqueness, rarity, northern/southern limit of range, etc.). While New Hampshire presently has no laws protecting these species, their presence should not be dismissed.

Discussions with New Hampshire Fish and Game revealed that virtually all rivers in this study have native cold water fisheries plus many are stocked. No attempt was made to describe the extent of recreation these areas provide. Anadromous fish were evaluated under three criteria - presently found, potential to support and planned introduction or re-introduction. As with cold water fisheries, many rivers presently support anadromous fish populations. Federal law prohibits construction of impassable barriers where these fish are found. No conflict is anticipated at most proposed sites since they are far enough inland to be beyond the migratory range of any anadromous fish.

The unique features criteria was used as a general category for various unusual or interesting characteristics that were known to exist at project locations. This list is far from complete since field surveys at each site are the most reliable method of documenting those occurrences. The unique feature list includes sites containing furbearing mammals, sea-run salmon, a quaking bog, cottontail and pheasant habitat (cottontail are considered threatened in New Hampshire) and sites with historical or cultural resources.

Finally, plus marks were totaled for all criteria met at each site. As stated before, sites were ranked only against other sites within the same group. When two or more sites within a group obtained the same score, the safe yield for each impoundment was used to determine rank. Those sites with higher yields were considered more desirable to develop.

In summary, it should be remembered that the available information provided in part by the New Hampshire Fish and Game Department and the 1977 New Hampshire Outdoor Recreation Plan did not permit a definitive study of potential sites. Rather the information is better used as a starting point for evaluating sites and highlighting potential areas of concern.

Alternative 2, local surface water development and alternative 3, regional surface water development were formed utilizing the 29 potential reservoir sites remaining after the initial screening. These alternatives are discussed in detail in the next section. Alternatives 4 and 5, which involve combinations of management measures, consist of some of the reservoir sites which appear most feasible at this time. However, none of the 29 potential sites have been completely eliminated from further study and will not be until the next series of public workshops has been completed.

2. Groundwater Development - Potential aquifer sites were identified and delineated from existing information in geological and hydrological reports and maps for the study area. For the purposes of this study a potential aquifer site was considered only if it was capable of supplying a large enough yield to warrant development as a municipal supply. Criteria established for aquifer consideration was a minimum saturated thickness of 20 feet and a minimum safe yield of 150 gallons per minute (gpm). Applying the above criteria to existing information resulted in delineation of 81 potential aquifer sites.

A thorough literature review of existing information and a field check was conducted for each site. The purpose of the field check was to verify the size and location of the aquifers and to evaluate the current land use with respect to aquifer availability. Field reconnaissance included a check on topographic features, vegetation, surface soil types, geological formations and any excavations which might expose subsurface conditions. Any manmade features which might affect quality or development of the aquifer were also noted. Based on all field observations and summarized literature findings, an attempt was made to evaluate the potential of the individual aquifers. In some areas because of limited access, surficial till deposits, absence of subsurface explorations or a lack of existing information, the observations were not conclusive and complete evaluation of potential was not possible. Modifications to the aquifer delineations were made where indicated as a result of field investigations. These field checks resulted in the number of aquifers warranting further investigation being reduced from the original 81 aquifers to 56 aquifers, as shown on Plate 3.

The next step was to determine the quantity and quality of groundwater in the 56 potential sites. A methodology based on existing available data was developed for the quantitative analysis. All available seismic work, boring logs and well driller's logs were collected and analyzed. Updated site maps with assumed geology were developed. The 56 sites were then reevaluated on their potential as municipal water supply sources. Estimates of the safe sustained yield were made for each aquifer. The degree of reliability for each site varied with the amount of available information. Recommendations were made on the advisability of further exploration for each site. The groundwater investigations conducted for this study generated



a considerable amount of data on the study area's groundwater resources. Results of these investigations are presented in detail in a report entitled "Groundwater Assessment for Southeastern New Hampshire". This report will be released as a separate document as State and local officials have indicated a strong interest in this phase of the study. To date an extensive evaluation of the region's groundwater resources has been made.

Some of the aquifers identified are already developed to, or close to their safe yield. Communities using any aquifer can be expected to continue developing that aquifer up to its safe yield before seeking a new source. Therefore, aquifers that are highly developed were not considered as viable elements in new water supply alternatives. Thus in the final analysis, 20 potential aquifer sites were deemed capable of being developed as municipal sources to meet projected 2030 deficits in the study area.

Alternative 1, complete development of groundwater, was formulated to determine the study area's ability to meet future demands with groundwater resources only. Of the 28 communities expected to require additional water supplies by 2030 only 11 will be able to meet these demands with groundwater resources. Thus, as the case with alternatives 2 and 3 for surface water, groundwater development by itself cannot meet projected 2030 demands.

3. Diversion - Alternative 6 was formulated to meet future demands by an out-of-basin diversion. Lake Winnepesaukee was evaluated as a source of water supply for study area communities. Over 125 miles of transmission lines would be required to transport the water to the study area. This single source is capable of meeting projected 2030 demands for the entire study area.

There are considerable social, economic and environmental impacts associated with development of Lake Winnepesaukee as a water supply source. The lake is one of the most extensively utilized recreational lakes in New England. Competing water use is a critical consideration for Lake Winnepesaukee. Downstream water rights and riparian rights issues would be a major undertaking. An extensive mitigation plan would have to be initiated to provide policy and jurisdiction over use of the lake. This alternative would not appear to be the most practical method to solving future water supply requirements both from an engineering and public acceptance viewpoint.

The New Hampshire Water Supply and Pollution Control Commission has been studying the feasibility of diverting flow from the Merrimack River to supply the Hudson-Pelham-Windham-Salem area. The institutional aspects of this plan are significant. As these communities border the State of Massachusetts an interstate agreement for providing downstream flow will have to be worked out. The Merrimack River is currently being utilized as a water supply source for communities in Massachusetts. Associated adverse environmental impacts of this plan would be similar to those discussed for the Lake Winnepesaukee diversion.

Results of this investigation will be compared with other proposed plans to supply this region and an evaluation of the trade-offs between the plans will be made.

4. Conservation - Conservation measures could have the effect of reducing the scale, and/or altering the timing of water resource projects. Water conservation measures could result in the delay of capital outlays for development of new sources of supply. In some cases conservation could preclude the need for a regional system by reducing the number of communities to be considered. Significant cost savings could be realized in the building of water treatment and wastewater treatment plants as size requirements for the plant could be reduced.

Demands shown in this report do not reflect the effects of water conservation measures. Evaluation of the effectiveness and social acceptability of a water conservation program for Southeast New Hampshire will be completed before future alternatives are finalized.

5. Desalination - The feasibility of converting salt or brackish water to potable water was considered as an alternative management measure for the seacoast region. The process of desalination is currently used to meet the water supply needs of various communities in other parts of the world. In regions where fresh water resources are limited, such as the Mid-East countries, desalination has proven economically feasible. The four major processes for converting saline water to fresh water are distillation-evaporation, membrane separation, crystallization and chemical differentiation.

Several impacts prevent desalination from being a viable alternative. High annual cost of operation as compared to conventional water treatment costs is the most significant impact. The current cost of desalting sea water is about \$4-6 per thousand gallons and \$1 per thousand gallons for brackish water. These costs are based on an output capacity of 1 mgd. The cost is dependent upon the plant capacity, type of treatment process and power source. Even when larger capacity plants are put into use the unit cost of conventional treatment of natural water resources is significantly more economical. Disposal of the brine which is an effluent produced from the process would have severe environmental impacts. Until the state of the art of desalination is improved, and the process becomes more technically and economically feasible, desalination will not be considered a viable alternative for the study area.

As part of the Federal Government's Saline Water Conversion Program administered by the Office of Water Research and Technology, the community of Seabrook has been selected as a potential site for a pilot desalination plant. The progress of this study will be closely monitored as it impacts upon alternatives developed for Southeastern New Hampshire.

SECTION IV

DESCRIPTION ASSESSMENT AND  
EVALUATION OF PRELIMINARY PLANS

#### IV. DESCRIPTION, ASSESSMENT AND EVALUATION OF PRELIMINARY PLANS

This section presents those alternatives which have been formulated to meet the study planning objectives. Plans presented in this section have passed the initial planning screening. Alternatives considered but not passing the screening were described in the previous section. The cost tables following each alternative present a breakdown of its major components followed by the total cost of the alternative.

##### ALTERNATIVE 1: Local Groundwater Development

Alternative 1 is based on maximum development of local groundwater supplies. This alternative was evaluated to determine the ability of groundwater development as a single management measure capable of meeting the projected 2030 demands for the study area. There is strong public interest in maximizing the region's groundwater resources.

Development of groundwater supplies is, for many communities, an important option in meeting increases in water demand. Groundwater supplies are generally less expensive to develop and have lower operating costs than surface water supplies of equal size. Well supplies in the study area often produce high quality water, require little treatment and often can be located so as to minimize environmental impacts.

Out of 28 communities which are expected to have a water supply deficit by 2030, only 11 will be able to supply their needs with local groundwater sources. The remaining 17 communities will have to develop local surface water supplies or be incorporated into regional systems.

The communities with sufficient groundwater resources to meet 2030 deficits are Barrington, Brentwood, Deerfield, Epping, Fremont, Kensington, Newton, Pelham, Raymond, Rochester, and Wakefield. The costs associated with the development of groundwater within each community are presented in Table 11. Costs include wellfield development and transmission to the need area. The total capital cost for this alternative is \$12,323,000 to supply an average day flow of 5.59 mgd and a maximum day flow of 16.93 mgd.

Groundwater aquifers were selected based on their estimated safe yield and location to the need area. The location of each aquifer and the community which it serves are shown on Plate 4.

Construction and operation of the wells under this alternative will be the responsibility of local communities since each wellfield is to be located within the community which it will serve. For this same reason, institutional impacts will be minimal or nonexistent.

Public response is usually favorable to groundwater development due to the low cost and minimal social and environmental impacts. Many of the communities in Southeastern New Hampshire are presently supplied by groundwater.

TABLE 11

COST SUMMARY

ALTERNATIVE 1: Local Groundwater Development

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Wakefield	Wellfield	Aquifer WA-1	
		Capital Cost	174.0
	O&M Cost	4.1	
	Transmission	Capital Cost	379.0
O&M Cost		3.0	
TOTAL CAPITAL COST			553.0
ANNUAL COST			47.8
UNIT COST			2.62

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Rochester	Wellfield	Aquifer RO-2	
		Capital Cost	2230.0
	O&M Cost	26.5	
	Transmission	Capital Cost	1841.1
O&M Cost		22.1	
TOTAL CAPITAL COST			4071.0
ANNUAL COST			348.2
UNIT COST			0.67

NOTE: Capital Costs 1000 \$  
O&M Costs and Annual Costs 1000 \$/year  
Unit Costs \$/1000 gallons  
Annual cost includes O&M cost and amortization of capital cost

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Barrington	Wellfield	Aquifer BA-1	
		Capital Cost	432.0
	O&M Cost	10.9	
	Transmission	Capital Cost	690.0
		O&M Cost	33.4
TOTAL CAPITAL COST			1122.0
ANNUAL COST			126.9
UNIT COST			0.40

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Deerfield	Wellfield	Aquifer DE-1	
		Capital Cost	308.0
	O&M Cost	7.9	
	Transmission	Capital Cost	1361.0
		O&M Cost	22.0
TOTAL CAPITAL COST			1669.0
ANNUAL COST			152.7
UNIT COST			0.89

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Epping	Wellfield	Aquifer EP-2	
		Capital Cost	184.0
	O&M Cost	4.4	
	Transmission	Capital Cost	798.0
O&M Cost		6.7	
			<hr/>
TOTAL CAPITAL COST			982.0
ANNUAL COST			83.3
UNIT COST			1.09

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Raymond	Wellfield	Aquifer RA-1	
		Capital Cost	440.0
	O&M Cost	9.5	
	Transmission	Capital Cost	285.0
O&M Cost		9.5	
			<hr/>
TOTAL CAPITAL COST			725.0
ANNUAL COST			72.4
UNIT COST			0.30

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Fremont	Wellfield	Aquifer FR-3	
		Capital Cost	182.0
	O&M Cost	4.4	
	Transmission	Capital Cost	581.0
O&M Cost		6.0	
			<hr/>
TOTAL CAPITAL COST			763.0
ANNUAL COST			66.5
UNIT COST			0.87

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Brentwood	Wellfield	Aquifer BW-2	
		Capital Cost	184.0
	O&M Cost	4.6	
	Transmission	Capital Cost	980.0
O&M Cost		9.8	
			<hr/>
TOTAL CAPITAL COST			1164.0
ANNUAL COST			100.0
UNIT COST			0.94

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Kensington	Wellfield	Aquifer KE-1	
		Capital Cost	58.0
	O&M Cost	2.3	
	Transmission	Capital Cost	65.0
		O&M Cost	2.6
			TOTAL CAPITAL COST
		ANNUAL COST	13.9
		UNIT COST	0.27

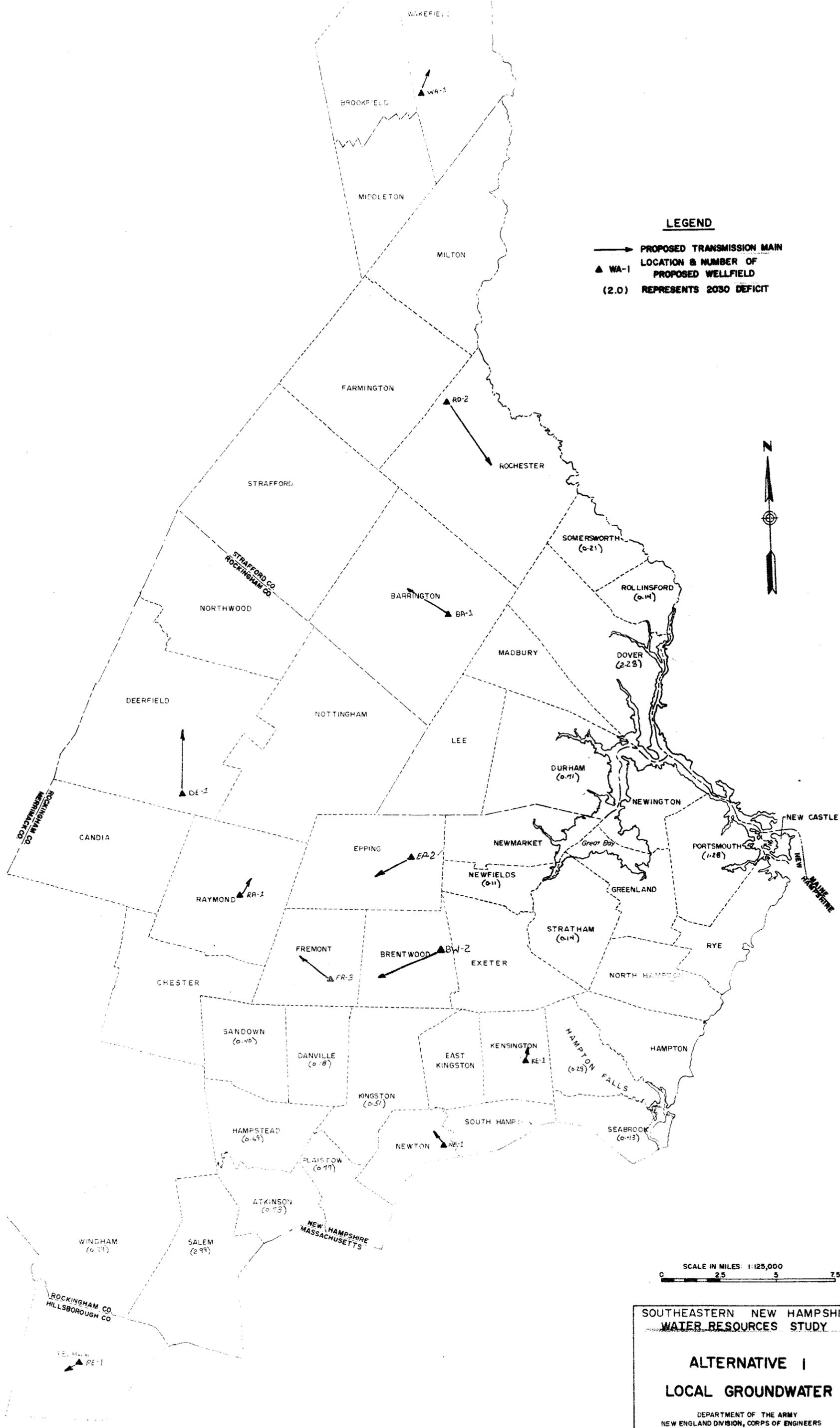
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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Newton	Wellfield	Aquifer NE-1	
		Capital Cost	300.0
	O&M Cost	7.1	
	Transmission	Capital Cost	245.0
		O&M Cost	8.5
			TOTAL CAPITAL COST
		ANNUAL COST	55.7
		UNIT COST	0.31

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Pelham	Wellfield	Aquifer PE-1	
		Capital Cost	420.0
	O&M Cost	9.9	
	Transmission	Capital Cost	186.0
		O&M Cost	10.1
TOTAL CAPITAL COST			606.0
ANNUAL COST			64.6
UNIT COST			0.23

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TOTAL CAPITAL COST - ALTERNATIVE 1	<u>12,323.00</u>
TOTAL ANNUAL COST	<u>1,132.00</u>



SOUTHEASTERN NEW HAMPSHIRE  
 WATER RESOURCES STUDY

**ALTERNATIVE I**  
**LOCAL GROUNDWATER**

DEPARTMENT OF THE ARMY  
 NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
 WALTHAM, MASS.

## ALTERNATIVE 2: Local Surface Water Development

This alternative considers development of just local surface water supplies to meet the 2030 needs of the study area. For some communities in the study area, developing their own surface water supplies provides the best solution to meeting increases in water consumption, especially in cases where groundwater supplies are inadequate or unavailable and regionalization is impractical. Assessment has shown that development of local surface water alone is not sufficient to meet the study's planning objectives.

Twelve communities are able to meet their 2030 deficits by developing local surface water supplies as shown on Plate 5. Each of these communities and their potential surface water supplies are discussed below. The costs of reservoir development, transmission and water treatment for each site are presented in Table 12.

Reservoir number 20 has been identified as a potential surface water supply to serve Deerfield and Nottingham. This reservoir has a safe yield of 2.5 mgd which is adequate to meet the .74 mgd 2030 average day deficit of the two communities. Located on the Bean River, reservoir number 20 has been considered a good site with little or no social and environmental impacts. Reservoir numbers 22 and 25 have also been identified as potential sources for Deerfield although impacts and relocations are higher than those associated with reservoir number 20. The reservoir area is forested with some swale. The valley is long and narrow with a flat bottom and steep sides.

Reservoir number 38, located on the Oyster River has been proposed as a local surface water supply for Dover and Durham. Other local sources for these two communities include reservoir number 37, also located on the Oyster River, and reservoir numbers 16 and 17 located on the Isinglass River. Reservoir numbers 37 and 38 provide the least cost alternatives for Dover and Durham although environmental and social impacts are much higher than those associated with reservoirs 16 and 17, which also provide a much greater safe yield. Downstream impacts could be substantial for reservoir 38. Extensive amounts of the reservoir area would be shallow. Dikes would also be required to retain backwater.

Reservoir 27 is the only local surface water supply available to serve Epping. This reservoir has a safe yield of 3.9 mgd. Environmental and social impacts are very low for this site, but the unit cost of development is extremely high (\$7.36/1000 gallons). The reservoir area is swamp with forested side slopes and some fields.

Reservoir 43 and 44 have been selected as local sources to serve Portsmouth. Both reservoirs are located on the Winnicut River and have low to moderate social and environmental impacts. Reservoir 43 has a much higher safe yield at a slightly greater cost and therefore appears to be the better alternative for Portsmouth at this time. A major portion of the reservoir area for reservoir 43 would be quite shallow (less than 15 feet depth). Some relocation would be required along existing roadways in the reservoir areas.

Reservoir 49 has been identified as the best local surface water source to serve Hampton. The only other possible local surface water source is reservoir 44 which has a lower safe yield at a much higher cost. Both reservoirs have low to moderate environmental impacts, but the associated social impacts are greater for reservoir 44. Reservoir 49 has a broad, flat valley with meandering streams. The valley narrows at the dam site but would still leave considerable area with shallow depths. Electric power transmission lines traversing the reservoir would have to be relocated.

Reservoir 54, located on Kelly Brook, has been identified as the only local surface water supply available to serve Plaistow. This reservoir has a safe yield of 1.5 mgd and a unit cost of \$1.81/1000 gallons. The reservoir area is primarily forested.

Reservoir 51, located on Hog Hill Brook, has been potentially identified to serve Atkinson. This reservoir has a safe yield of 4.5 mgd and a unit cost of \$4.05/1000 gallons. Development of this site would require the relocation of approximately 5 homes and of a small segment of a secondary road. A large percentage of the reservoir area is forested.

Reservoir 30, located on the Exeter River has been proposed as a local surface water supply to serve Sandown. This reservoir has a safe yield of 2.6 mgd and a unit cost of \$2.41/1000 gallons. Development of this site would have little impact on existing environmental and social conditions in the area. The reservoir area is a forested area which is primarily inaccessible at this time.

The only local surface water supply available to serve Pelham is reservoir 53. This reservoir has a safe yield of 1.3 mgd and a unit cost of \$2.71/1000 gallons. Extensive relocation of homes would be required if this site were to be developed. There are also several new subdivisions under development which could eventually make development of this site infeasible.

Development of local surface water does not provide adequate water supply for the entire study area as shown on Plate 5. Local surface water supplies, therefore, must be combined with other sources to provide the necessary future needs of the communities.

Institutional impacts are very low with the development of local supplies as only one or possibly two communities would be involved in the development of the water supply.

Residents usually look favorable upon local surface water supplies as the construction is on a smaller scale, therefore, minimizing environmental and social impacts as well as overall costs to the communities.

TABLE 12

COST SUMMARY

ALTERNATIVE 2: Local Surface Water Development

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>		
Rochester	Reservoir	Reservoir #12		
		Capital Cost	5,380.0	
	O&M Cost	39.3		
	Transmission	Capital Cost	1,970.0	
		O&M Cost	5.2	
	Water Treatment	Capital Cost	6,000.0	
		O&M Cost	44.0	
			TOTAL CAPITAL COST	13,380.0
			ANNUAL COST	1,082.1
		UNIT COST	2.07	

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>		
Deerfield Nottingham	Reservoir	Reservoir #20		
		Capital Cost	3,230.0	
	O&M Cost	29.6		
	Transmission	Capital Cost	2,020.0	
		O&M Cost	13.4	
	Water Treatment	Capital Cost	2,800.0	
		O&M Cost	22.0	
			TOTAL CAPITAL COST	8,100.0
			ANNUAL COST	657.0
		UNIT COST	2.43	

NOTE: Capital Costs 1000 \$  
 O&M Costs and Annual Costs 1000 \$/year  
 Unit Costs \$/1000 gallons  
 Annual cost includes O&M cost and amortization of capital cost

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Dover	Reservoir	Reservoir #38	
Durham		Capital Cost	5,930.0
		O&M Cost	37.2
	Transmission	Capital Cost	3,830.0
		O&M Cost	261.0
	Water Treatment	Capital Cost	8,800.0
		O&M Cost	95.0
		TOTAL CAPITAL COST	18,600.0
		ANNUAL COST	1,759.2
		UNIT COST	1.64

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Epping	Reservoir	Reservoir #27	
		Capital Cost	3,670.0
		O&M Cost	36.0
	Transmission	Capital Cost	1,570.0
		O&M Cost	9.3
	Water Treatment	Capital Cost	1,700.0
		O&M Cost	7.0
		TOTAL CAPITAL COST	6,900.0
		ANNUAL COST	564.2
		UNIT COST	7.36

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Portsmouth	Reservoir	Reservoir #43	
		Capital Cost	6,010.0
		O&M Cost	36.3
	Transmission	Capital Cost	3,400.0
		O&M Cost	25.6
		Water Treatment	Capital Cost
	O&M Cost		45.0
	TOTAL CAPITAL COST		15,800.0
	ANNUAL COST	1,271.3	
UNIT COST	2.72		

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Hampton	Reservoir	Reservoir #49	
		Capital Cost	3,020.0
		O&M Cost	32.4
	Transmission	Capital Cost	3,460.0
		O&M Cost	62.8
		Water Treatment	Capital Cost
	O&M Cost		87.0
	TOTAL CAPITAL COST		13,300.0
	ANNUAL COST	1,160.0	
UNIT COST	1.32		

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Plaistow	Reservoir	Reservoir #54	
		Capital Cost	2,170.0
		O&M Cost	23.9
	Transmission	Capital Cost	1,160.0
		O&M Cost	11.2
	Water Treatment	Capital Cost	2,800.0
		O&M Cost	23.0
		TOTAL CAPITAL COST	6,100.0
		ANNUAL COST	510.0
	UNIT COST	1.81	

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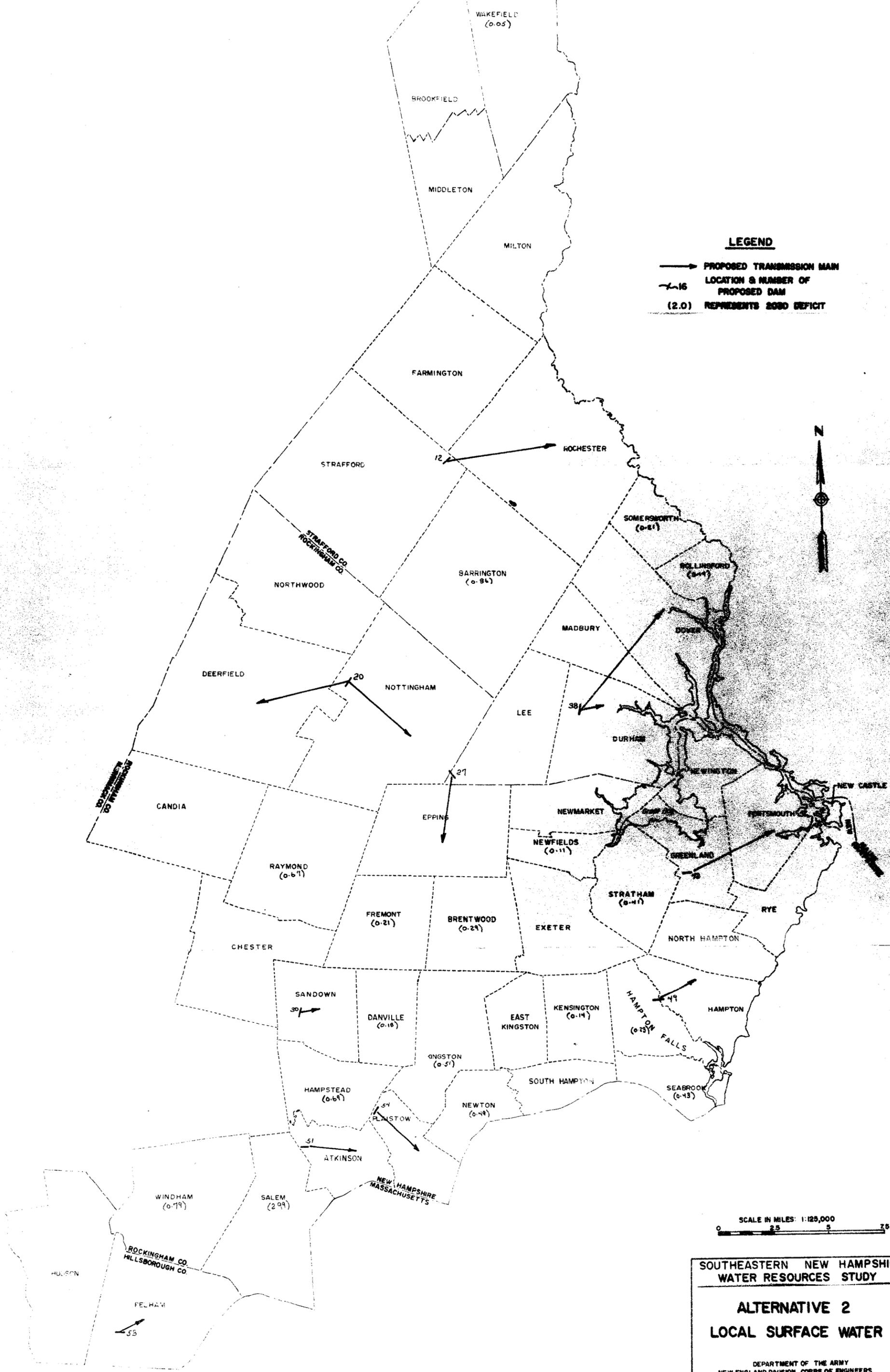
<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Atkinson	Reservoir	Reservoir #51	
		Capital Cost	9,470.0
		O&M Cost	36.8
	Transmission	Capital Cost	1,260.0
		O&M Cost	32.2
	Water Treatment	Capital Cost	2,700.0
		O&M Cost	22.0
		TOTAL CAPITAL COST	13,400.0
		ANNUAL COST	1,079.9
	UNIT COST	4.05	

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Sandown	Reservoir	Reservoir #30	
		Capital Cost	1,790.0
		O&M Cost	21.1
	Transmission	Capital Cost	470.0
		O&M Cost	5.3
	Water Treatment	Capital Cost	2,000.0
		O&M Cost	12.0
		TOTAL CAPITAL COST	4,260.0
		ANNUAL COST	351.9
	UNIT COST	2.41	

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Pelham	Reservoir	Reservoir #53	
		Capital Cost	5,650.0
		O&M Cost	23.7
	Transmission	Capital Cost	1,030.0
		O&M Cost	17.2
	Water Treatment	Capital Cost	2,800.0
		O&M Cost	23.0
		TOTAL CAPITAL COST	9,500.0
		ANNUAL COST	762.4
	UNIT COST	2.71	

TOTAL CAPITAL COST - ALTERNATIVE 2	<u>109,340.0</u>
TOTAL ANNUAL COST	<u>9,198.0</u>



**LEGEND**

- PROPOSED TRANSMISSION MAIN
- 16 LOCATION & NUMBER OF PROPOSED DAM
- (2.0) REPRESENTS 2000 DEFICIT



SCALE IN MILES: 1:125,000  
 0 2.5 5 7.5

SOUTHEASTERN NEW HAMPSHIRE  
 WATER RESOURCES STUDY

**ALTERNATIVE 2**  
**LOCAL SURFACE WATER**

DEPARTMENT OF THE ARMY  
 NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
 WALTHAM, MASS.

### ALTERNATIVE 3: Regional Surface Water Development

Alternative 3 examines ways in which communities may be grouped into regional and subregional systems to develop a small number of sources while maximizing use of the study area's resources. Regional systems allow the communities to share development costs which might otherwise be too great for any one community. Selection of communities incorporated into regional systems was based on reservoir safe yield, community needs and location. Communities not expected to develop a municipal system on their own but located on a regional transmission line route were served for this alternative.

Twenty-four communities are involved in the regional systems shown on Plate 6. Costs for reservoir development, transmission, and water treatment are presented in Table 13. The reservoirs discussed below were found to be the most likely to be developed, based on cost and the evaluation of social and environmental impacts to date. Other options, as noted, will not be eliminated until such time as all impacts have been further evaluated.

Reservoir 16, located on the Isinglass River, has a safe yield of 18.9 mgd. This reservoir has the potential to serve the communities of Barrington, Dover, Durham, Rochester and Portsmouth. Environmental and social impacts associated with development of this site are low to moderate. A major portion of this reservoir widens out over swampy areas. Evaluation of the effects development of the site may have on dilution of sewage effluent in lower reaches of the Cocheco River will be necessary. The total unit cost of development of this regional system is \$2.65/1000 gallons. Other options available to this area include the development of reservoirs 6,7,10 and 17 either singularly or in combinations.

Reservoir 20, located on the Bean River with a safe yield of 2.5 mgd, has been identified as a regional supply for Deerfield and Nottingham at a unit cost of \$2.43/1000 gallons. This reservoir was discussed in Alternative 2. Reservoir 25 is available as an optional supply source for this area.

Reservoir 49, located on the Taylor River, has been proposed to serve Hampton, Hampton Falls and Seabrook. This reservoir has a safe yield of 3.4 mgd and would cost \$1.49/1000 gallons to develop. Environmental impacts are considered low and social impacts are considered low to moderate. This reservoir provides the only structural water supply alternative available to Seabrook and Hampton Falls and was described under Alternative 2. Hampton on the other hand, has the option of joining Portsmouth in developing reservoir 43 into a regional system to serve both their needs.

Reservoir 31, located on the Exeter River, has been identified as a potential regional supply to serve East Kingston, Kingston, Danville, Hampstead, Atkinson, Plaistow and Salem. This reservoir has a safe yield of 42.2 mgd and a development cost of \$3.03/1000 gallons. Major environmental and social impacts are associated with the development of this site, due to the large area which would be inundated. Another option available to all of these communities except East Kingston and Kingston, would be the development of reservoir 28.

Reservoir 29, located on the Exeter River, has a safe yield of 3.5 mgd. This site could be developed to serve Chester, Sandown and Hampstead at a cost of \$1.69/1000 gallons. Hampstead has the option of being served by this reservoir or reservoir 31 if both were to be developed.

Reservoir 52, located on Beaver Brook, has been identified as a potential regional supply to serve Windham, Pelham and Salem. This reservoir has a safe yield of 13.2 and a unit cost of \$2.28/1000 gallons. However, relocations of roads and homes would be high for this site as some recent development was evident in the area.

Regional surface water systems have the advantage of being the most economical means to develop large water supplies, but other problems arise involving institutional arrangements between communities served by the system. State involvement would be necessary for the development and management of the systems.

Public response is less favorable toward regional development due to increases in relocations and environmental and social impacts associated with such large scale projects. The need to develop some type of regional or subregional plans is becoming more evident in parts of this study area. Future plans should be developed now rather than after the fact which is commonly the case.

TABLE 13  
COST SUMMARY

ALTERNATIVE 3: Regional Surface Water Development

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Rochester Somersworth Rollinsford Dover	Reservoir	Reservoir #7 (Optional)	
		Capital Cost	4,560.0
		O&M Cost	33.5
	Transmission	Capital Cost	20,300.00
		O&M Cost	864.90
	Water Treatment	Capital Cost	12,500.00
		O&M Cost	130.00
		TOTAL CAPITAL COST	37,400.0
		ANNUAL COST	3,778.8
		UNIT COST	2.58

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Rochester Barrington Dover Durham Portsmouth	Reservoir	Reservoir #16	
		Capital Cost	5,290.0
		O&M Cost	39.9
	Transmission	Capital Cost	24,500.0
		O&M Cost	2,606.9
	Water Treatment	Capital Cost	17,000.0
		O&M Cost	210.0
		TOTAL CAPITAL COST	46,800.0
		ANNUAL COST	6,299.8
		UNIT COST	2.65

NOTE: Capital Costs 1000 \$  
 O&M Costs and Annual Costs 1000 \$/year  
 Unit Costs \$/1000 gallons  
 Annual cost includes O&M cost and amortization of capital cost  
 Total costs include optional plan costs.

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Deerfield Nottingham	Reservoir	Reservoir #20	
		Capital Cost	3,230.0
	O&M Cost	29.6	
	Transmission	Capital Cost	2,020.0
		O&M Cost	13.4
	Water Treatment	Capital Cost	2,800.0
		O&M Cost	22.0
	TOTAL CAPITAL COST		8,100.0
	ANNUAL COST		657.0
UNIT COST		2.43	

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Deerfield Candia	Reservoir	Reservoir #25 (Optional)	
		Capital Cost	4,980.0
	O&M Cost	26.2	
	Transmission	Capital Cost	3,010.0
		O&M Cost	72.5
	Water Treatment	Capital Cost	2,900.0
		O&M Cost	22.0
	TOTAL CAPITAL COST		10,900.0
	ANNUAL COST		922.3
UNIT COST		3.32	

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Hampton Hampton Falls Seabrook	Reservoir	Reservoir #49	
		Capital Cost	3,020.0
		O&M Cost	32.4
	Transmission	Capital Cost	3,370.0
		O&M Cost	383.1
	Water Treatment	Capital Cost	9,100.0
		O&M Cost	103.0
		TOTAL CAPITAL COST	15,500.0
		ANNUAL COST	1,659.0
	UNIT COST	1.49	

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Portsmouth Hampton	Reservoir	Reservoir #43 (Optional)	
		Capital Cost	6,010.0
		O&M Cost	36.3
	Transmission	Capital Cost	8,500.0
		O&M Cost	862.0
	Water Treatment	Capital Cost	11,000.0
		O&M Cost	120.0
		TOTAL CAPITAL COST	22,500.0
		ANNUAL COST	2,896.0
	UNIT COST	2.16	

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
E. Kingston	Reservoir	Reservoir #31	
Kingston		Capital Cost	24,870.0
Danville		O&M Cost	83.5
Hampstead	Transmission	Capital Cost	19,760.0
Atkinson		O&M Cost	2,189.7
Plaistow	Water Treatment	Capital Cost	11,700.0
Salem		O&M Cost	195.0
TOTAL CAPITAL COST			56,300.0
ANNUAL COST			6,615.8
UNIT COST			3.03

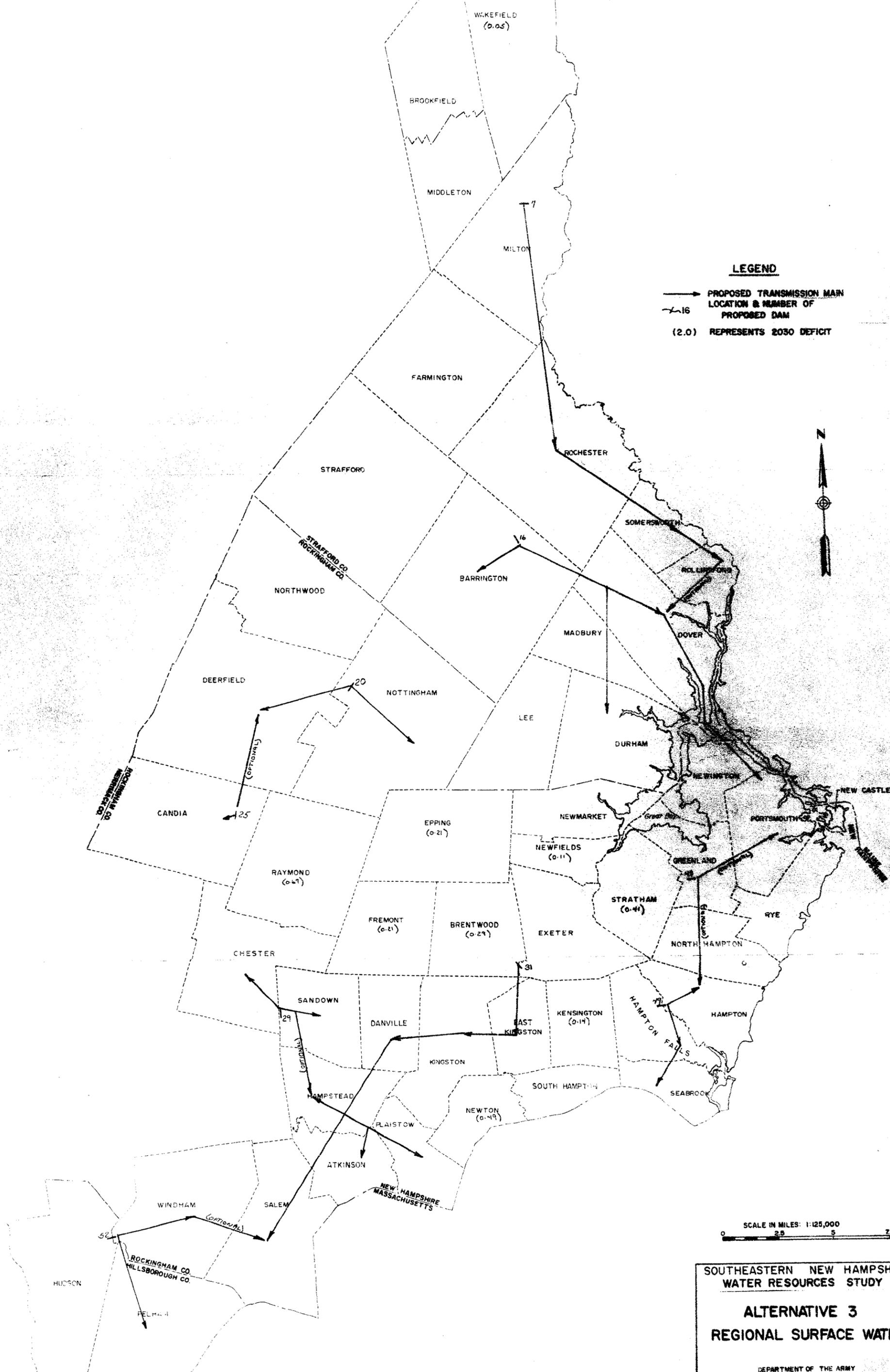
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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Chester	Reservoir	Reservoir #29	
Sandown		Capital Cost	4,490.0
Hampstead (Optional)		O&M Cost	33.4
	Transmission	Capital Cost	3,320.0
		O&M Cost	144.0
	Water Treatment	Capital Cost	4,100.0
		O&M Cost	44.0
TOTAL CAPITAL COST			11,900.0
ANNUAL COST			857.1
UNIT COST			1.69

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>		
Windham Pelham Salem (Optional)	Reservoir	Reservoir #52		
		Capital Cost	13,200.0	
		O&M Cost	39.2	
	Transmission	Capital Cost	9,690.0	
		O&M Cost	1,139.4	
	Water Treatment	Capital Cost	10,500.0	
		O&M Cost	150.0	
	TOTAL CAPITAL COST			33,400.0
	ANNUAL COST			3,785.7
UNIT COST			2.28	

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TOTAL CAPITAL COST - ALTERNATIVE 3	<u>242,800.0</u>
TOTAL ANNUAL COST	<u>27,472.0</u>



**LEGEND**

- > PROPOSED TRANSMISSION MAIN
- /16 LOCATION & NUMBER OF PROPOSED DAM
- (2.0) REPRESENTS 2030 DEFICIT



SCALE IN MILES: 1:125,000  
 0 2.5 5 7.5

**SOUTHEASTERN NEW HAMPSHIRE  
 WATER RESOURCES STUDY**

**ALTERNATIVE 3  
 REGIONAL SURFACE WATER**

DEPARTMENT OF THE ARMY  
 NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
 WALTHAM, MASS

#### ALTERNATIVE 4: Development of Local Surface Water and Groundwater

Alternative 4 is based on the development of local water supplies. First priority is given to local sources of groundwater as it is generally less expensive to develop and associated impacts are less than for surface water development. If the town does not have sufficient groundwater to satisfy future demands, than surface water supplies within the town are evaluated. Under this alternative, eleven communities are able to develop sufficient groundwater, seven are able to develop local surface water and the remaining towns must look toward regional systems.

The communities of Barrington, Brentwood, Deerfield, Epping, Fremont, Kensington, Newton, Pelham, Raymond, Rochester and Wakefield have sufficient groundwater available as described in alternative 1, and are shown on Plate 7. The communities served by local surface water are also shown on Plate 7, and listed below. All costs associated with development of this alternative are presented in Table 14.

The following reservoirs are included in this alternative: reservoir 38 to serve Dover and Durham, reservoir 43 to serve Portsmouth, reservoir 49 to serve Hampton, reservoir 30 to serve Sandown, reservoir 54 to serve Plaistow and reservoir 51 to serve Atkinson .

Impacts associated with the development of these reservoirs were discussed under alternative 2, local surface water development.

Institutional impacts are minimal for this alternative, as is the case for local development when only one or sometimes two communities are involved.

Public response can be expected to be favorable due to the smallscale development and lower overall impacts.

TABLE 14

COST SUMMARY

ALTERNATIVE 4: Development of Local Surface Water and Groundwater

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Wakefield	Wellfield	Aquifer WA-1	
		Capital Cost	174.0
	O&M Cost	4.1	
	Transmission	Capital Cost	379.0
		O&M Cost	3.0
		TOTAL CAPITAL COST	553.0
		ANNUAL COST	47.8
		UNIT COST	2.62

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Rochester	Wellfield	Aquifer RO-2	
		Capital Cost	2,230.0
	O&M Cost	26.5	
	Transmission	Capital Cost	1,841.0
		O&M Cost	22.1
		TOTAL CAPITAL COST	4,071.0
		ANNUAL COST	348.2
		UNIT COST	0.67

NOTE: Capital Costs 1000 \$  
 O&M Costs and Annual Costs 1000 \$/year  
 Unit Costs \$/1000 gallons  
 Annual cost includes O&M cost and amortization of capital cost

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Barrington	Wellfield	Aquifer BA-1	
		Capital Cost	432.0
		O&M Cost	10.9
	Transmission	Capital Cost	690.0
		O&M Cost	33.4
	TOTAL CAPITAL COST		1,122.0
	ANNUAL COST		126.9
	UNIT COST		0.40

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Deerfield	Wellfield	Aquifer DE-1	
		Capital Cost	308.0
		O&M Cost	7.9
	Transmission	Capital Cost	1,361.0
		O&M Cost	22.0
	TOTAL CAPITAL COST		1,669.0
	ANNUAL COST		152.7
	UNIT COST		0.89

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>		
Dover Durham	Reservoir	Reservoir #38		
		Capital Cost	5,930.0	
		O&M Cost	37.2	
	Transmission	Capital Cost	3,830.0	
		O&M Cost	261.0	
	Water Treatment	Capital Cost	8,800.0	
		O&M Cost	95.0	
			TOTAL CAPITAL COST	18,600.0
			ANNUAL COST	1,759.2
		UNIT COST	1.64	

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>		
Portsmouth	Reservoir	Reservoir #43		
		Capital Cost	6,010.0	
		O&M Cost	36.3	
	Transmission	Capital Cost	3,400.0	
		O&M Cost	25.6	
	Water Treatment	Capital Cost	6,400.0	
		O&M Cost	45.0	
			TOTAL CAPITAL COST	15,800.0
			ANNUAL COST	1,271.3
		UNIT COST	2.72	

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Epping	Wellfield	Aquifer EP-2	
		Capital Cost	184.0
	O&M Cost	4.4	
	Transmission	Capital Cost	798.0
		O&M Cost	6.7
			TOTAL CAPITAL COST
		ANNUAL COST	83.3
		UNIT COST	1.09

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Raymond	Wellfield	Aquifer RA-1	
		Capital Cost	440.0
	O&M Cost	9.5	
	Transmission	Capital Cost	285.0
		O&M Cost	9.5
			TOTAL CAPITAL COST
		ANNUAL COST	72.4
		UNIT COST	0.30

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Fremont	Wellfield	Aquifer FR-3	
		Capital Cost	182.0
		O&M Cost	4.4
	Transmission	Capital Cost	581.0
		O&M Cost	6.0
		TOTAL CAPITAL COST	763.0
ANNUAL COST	66.5		
UNIT COST	0.87		

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Brentwood	Wellfield	Aquifer BW-2	
		Capital Cost	184.0
		O&M Cost	4.6
	Transmission	Capital Cost	980.0
		O&M Cost	9.8
		TOTAL CAPITAL COST	1,164.0
ANNUAL COST	100.0		
UNIT COST	0.94		

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>		
Hampton	Reservoir	Reservoir #49		
		Capital Cost	3,020.0	
	O&M Cost	32.4		
	Transmission	Capital Cost	3,460.0	
		O&M Cost	62.8	
	Water Treatment	Capital Cost	6,800.0	
		O&M Cost	87.0	
			TOTAL CAPITAL COST	13,300.0
			ANNUAL COST	1,160.0
		UNIT COST	1.32	

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Kensington	Wellfield	Aquifer KE-1	
		Capital Cost	58.0
	O&M Cost	2.3	
	Transmission	Capital Cost	65.0
		O&M Cost	2.6
			TOTAL CAPITAL COST
		ANNUAL COST	13.9
		UNIT COST	0.27

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Newton	Wellfield	Aquifer NE-1	
		Capital Cost	300.0
		O&M Cost	7.1
	Transmission	Capital Cost	245.0
		O&M Cost	8.5
		TOTAL CAPITAL COST	545.0
	ANNUAL COST	55.7	
	UNIT COST	0.31	

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Sandown	Reservoir	Reservoir #30	
		Capital Cost	1,790.0
		O&M Cost	21.1
	Transmission	Capital Cost	470.0
		O&M Cost	5.3
	Water Treatment	Capital Cost	2,000.0
		O&M Cost	12.0
		TOTAL CAPITAL COST	4,260.0
	ANNUAL COST	351.9	
	UNIT COST	2.41	

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Plaistow	Reservoir	Reservoir #54	
		Capital Cost	2,170.0
		O&M Cost	23.9
	Transmission	Capital Cost	1,160.0
		O&M Cost	11.2
	Water Treatment	Capital Cost	2,800.0
		O&M Cost	23.0
		TOTAL CAPITAL COST	6,100.0
		ANNUAL COST	510.0
	UNIT COST	1.81	

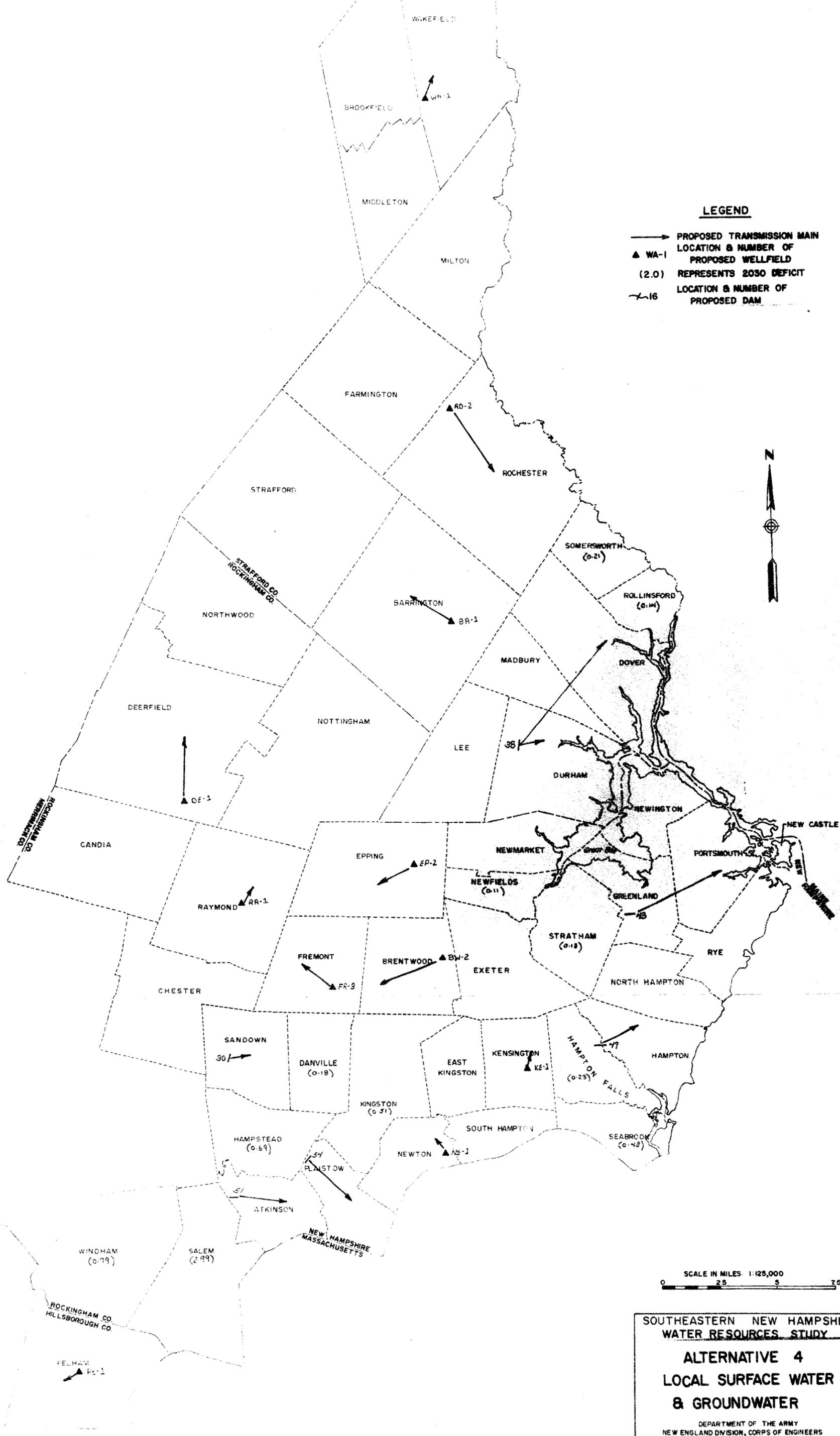
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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Atkinson	Reservoir	Reservoir #51	
		Capital Cost	9,470.0
		O&M Cost	36.8
	Transmission	Capital Cost	1,260.0
		O&M Cost	32.2
	Water Treatment	Capital Cost	2,700.0
		O&M Cost	22.0
		TOTAL CAPITAL COST	13,400.0
		ANNUAL COST	1,079.0
	UNIT COST	4.05	

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Pelham	Wellfield	Aquifer PE-1	
		Capital Cost	420.0
	O&M Cost	9.9	
	Transmission	Capital Cost	186.0
		O&M Cost	10.1
			TOTAL CAPITAL COST
		ANNUAL COST	64.6
		UNIT COST	0.23

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TOTAL CAPITAL COST - ALTERNATIVE 4	<u>83,783.0</u>
TOTAL ANNUAL COST	<u>7,264.3</u>



SOUTHEASTERN NEW HAMPSHIRE  
 WATER RESOURCES STUDY

**ALTERNATIVE 4**  
**LOCAL SURFACE WATER**  
**& GROUNDWATER**

DEPARTMENT OF THE ARMY  
 NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
 WALTHAM, MASS

## ALTERNATIVE 5: Combination Plan

Alternative 5, as shown on Plate 8, is a combination of those plans which best address the needs of the study area. The several options available to many communities were narrowed down to those which minimize environmental and social impacts, yet still remain cost effective. The costs associated with each segment of this alternative are presented in Table 15.

A major portion of this alternative involves the development of local and regional groundwater sources. Ten communities are able to develop local groundwater supplies to meet their long-term needs and an additional three communities are involved in a regional groundwater system. Groundwater development for these ten communities is the same as in alternative 1 with the exception of Rochester which is involved in the regional system. The regional system utilizes the high yield aquifers in Rochester to supply Rochester, Somersworth and Rollinsford at a cost of \$2.46/1000 gallons.

Surface water development consists of one local system and three regional systems serving a total of 15 communities. The one local system proposes development of reservoir 30 to serve Sandown as under alternative 2.

The three regional systems, involving development of reservoirs 16, 49, and 31, are similar to those proposed in alternative 3 with changes made only to the number of communities served by each system.

Reservoir 16, under this alternative, serves the communities of Dover, Durham and Portsmouth. However, Barrington which was previously included in this system, has sufficient groundwater to meet its long-term needs. This change reduced the cost from \$2.65/1000 gallons to \$2.43/1000 gallons.

Reservoir 49 and the communities of Hampton, Hampton Falls, and Seabrook which it serves, remain the same as was proposed under alternative 3.

Development of reservoir 31, under this alternative, includes the community of Windham along with the seven other communities previously served by this system under alternative 3. It was found more economical at this point for Windham to be included in this regional system than to develop its own reservoir. The added cost to add Windham to this system is \$6.3 million, or an increase from a unit cost of \$3.03/1000 gallons to \$3.21/1000 gallons.

The total capital cost of alternative 5 is \$137.9 million to serve a total of 28 communities.

Institutional impacts, as with any regional system are greater than those associated with local development. Therefore, those sections of this alternative which involve regional development will require special arrangements between towns and possibly State involvement for development and management.

Public response would vary in the development of this alternative due to the mixture of local and regional supplies.

TABLE 15  
COST SUMMARY

ALTERNATIVE 5: Combination Plan

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Wakefield	Wellfield	Aquifer WA-1	
		Capital Cost	174.0
	O&M Cost	4.1	
	Transmission	Capital Cost	379.0
O&M Cost		3.0	
TOTAL CAPITAL COST			553.0
ANNUAL COST			47.8
UNIT COST			2.62

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Rochester Somersworth Rollinsford	Wellfield	Aquifer RO-2	
		Capital Cost	4,360.0
	O&M Cost	39.0	
	Transmission	Capital Cost	7,830.0
O&M Cost		661.1	
TOTAL CAPITAL COST			12,190.0
ANNUAL COST			1,596.9
UNIT COST			2.46

NOTE: Capital Costs 1000 \$  
 O&M Costs and Annual Costs 1000 \$/year  
 Unit Costs \$/1000 gallons  
 Annual cost includes O&M cost and amortization of capital cost

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>		
Dover Durham Portsmouth	Reservoir	Reservoir #16		
		Capital Cost	5,290.0	
		O&M Cost	39.9	
	Transmission	Capital Cost	16,804.0	
		O&M Cost	995.6	
	Water Treatment	Capital Cost	13,000.0	
		O&M Cost	130.0	
			TOTAL CAPITAL COST	35,094.0
			ANNUAL COST	3,748.5
		UNIT COST	2.43	

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Barrington	Wellfield	Aquifer BA-1	
		Capital Cost	432.0
		O&M Cost	10.9
	Transmission	Capital Cost	690.0
		O&M Cost	33.4
			TOTAL CAPITAL COST
		ANNUAL COST	126.9
		UNIT COST	0.40

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Deerfield	Wellfield	Aquifer DE-1	
		Capital Cost	308.0
		O&M Cost	7.9
	Transmission	Capital Cost	1,361.0
		O&M Cost	22.0
		TOTAL CAPITAL COST	1,669.0
		ANNUAL COST	152.7
		UNIT COST	0.89

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Epping	Wellfield	Aquifer EP-2	
		Capital Cost	184.0
		O&M Cost	4.4
	Transmission	Capital Cost	798.0
		O&M Cost	6.7
		TOTAL CAPITAL COST	982.0
		ANNUAL COST	83.3
		UNIT COST	1.09

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Raymond	Wellfield	Aquifer RA-1	
		Capital Cost	440.0
	O&M Cost	9.5	
	Transmission	Capital Cost	285.0
		O&M Cost	9.5
			TOTAL CAPITAL COST
		ANNUAL COST	72.4
		UNIT COST	0.30

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Fremont	Wellfield	Aquifer FR-3	
		Capital Cost	182.0
	O&M Cost	4.4	
	Transmission	Capital Cost	581.0
		O&M Cost	6.0
			TOTAL CAPITAL COST
		ANNUAL COST	66.5
		UNIT COST	0.87

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Brentwood	Wellfield	Aquifer BW-2	
		Capital Cost	184.0
	O&M Cost	4.6	
	Transmission	Capital Cost	980.0
		O&M Cost	9.8
			TOTAL CAPITAL COST
		ANNUAL COST	100.0
		UNIT COST	0.94

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>		
Hampton Hampton Falls Seabrook	Reservoir	Reservoir #49		
		Capital Cost	3,020.0	
		O&M Cost	32.4	
	Transmission	Capital Cost	3,370.0	
		O&M Cost	383.1	
	Water Treatment	Capital Cost	9,100.0	
		O&M Cost	103.0	
			TOTAL CAPITAL COST	15,500.0
			ANNUAL COST	1,659.0
		UNIT COST	1.49	

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Kensington	Wellfield	Aquifer KE-1	
		Capital Cost	58.0
	O&M Cost	2.3	
	Transmission	Capital Cost	65.0
O&M Cost		2.6	
	TOTAL CAPITAL COST		123.0
	ANNUAL COST		13.9
	UNIT COST		0.27

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<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Newton	Wellfield	Aquifer NE-1	
		Capital Cost	300.0
	O&M Cost	7.1	
	Transmission	Capital Cost	245.0
O&M Cost		8.5	
	TOTAL CAPITAL COST		545.0
	ANNUAL COST		55.7
	UNIT COST		0.31

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
E. Kingston	Reservoir	Reservoir #31	
Kingston		Capital Cost	24,870.0
Danville		O&M Cost	83.5
Hampstead	Transmission	Capital Cost	24,740.0
Atkinson		O&M Cost	3,036.2
Plaistow	Water Treatment	Capital Cost	13,000.0
Salem		O&M Cost	220.0
Windham			
		TOTAL CAPITAL COST	62,610.0
		ANNUAL COST	7,948.5
		UNIT COST	3.21

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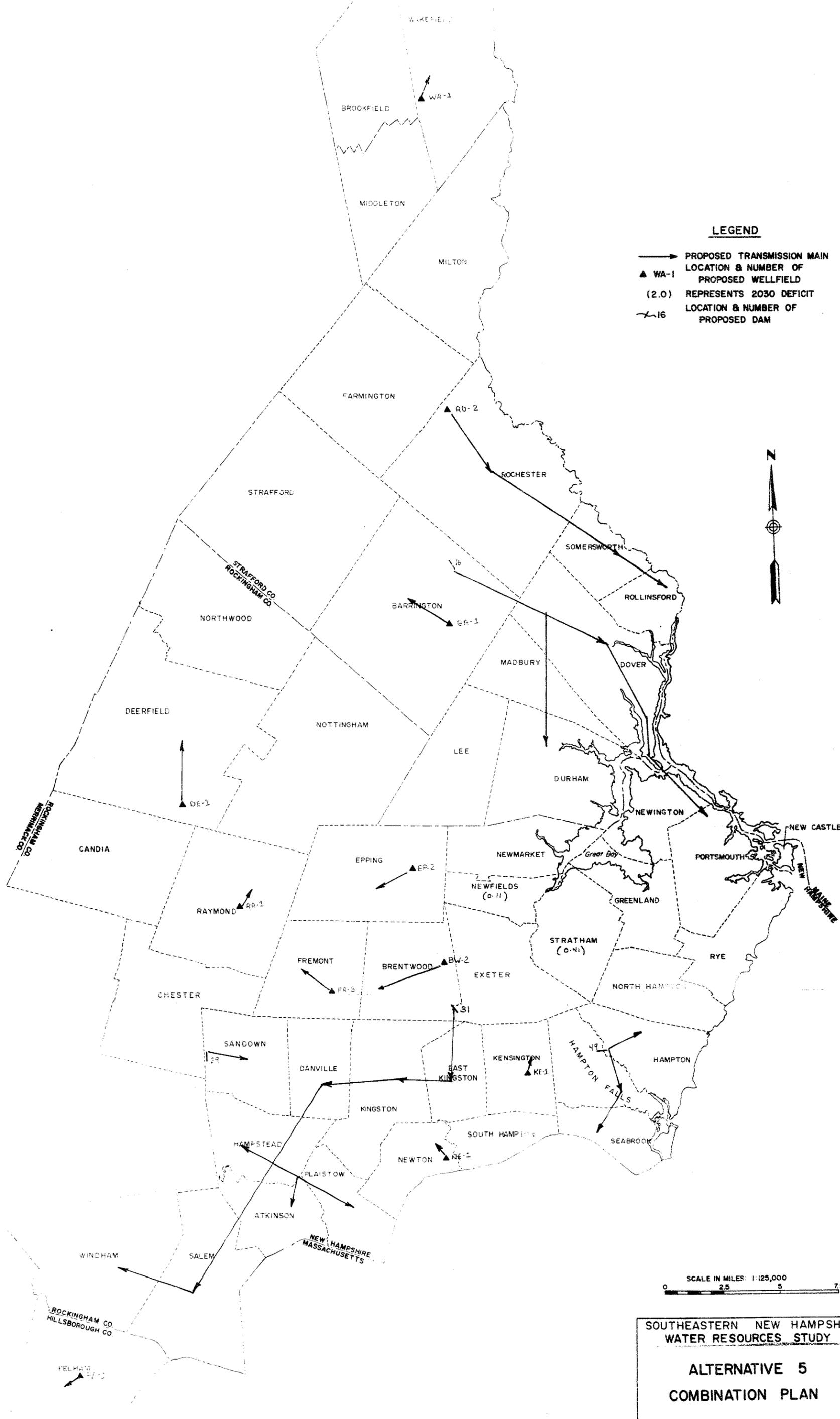
<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Sandown	Reservoir	Reservoir #30	
		Capital Cost	1,790.0
		O&M Cost	21.1
	Transmission	Capital Cost	470.0
		O&M Cost	5.3
	Water Treatment	Capital Cost	2,000.0
		O&M Cost	12.0
		TOTAL CAPITAL COST	4,260.0
		ANNUAL COST	351.9
		UNIT COST	2.41

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Pelham	Wellfield	Aquifer PE-1	
		Capital Cost	420.0
	O&M Cost	9.9	
	Transmission	Capital Cost	186.0
O&M Cost		10.1	

TOTAL CAPITAL COST	606.0
ANNUAL COST	64.6
UNIT COST	0.23

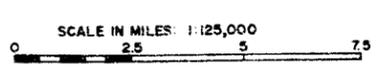
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TOTAL CAPITAL COST - ALTERNATIVE 5	137,906.0
TOTAL ANNUAL COST	16,088.6



**LEGEND**

- PROPOSED TRANSMISSION MAIN
- ▲ WA-1 LOCATION & NUMBER OF PROPOSED WELLFIELD
- (2.0) REPRESENTS 2030 DEFICIT
- 16 LOCATION & NUMBER OF PROPOSED DAM



SOUTHEASTERN NEW HAMPSHIRE  
 WATER RESOURCES STUDY

**ALTERNATIVE 5  
 COMBINATION PLAN**

DEPARTMENT OF THE ARMY  
 NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
 WALTHAM, MASS.

### ALTERNATIVE 6: Lake Winnepesaukee Diversion

This alternative considers diversion of water from Lake Winnepesaukee to serve as a regional source of water supply for the entire Southeastern New Hampshire study area. The communities served by this system would be Portsmouth, Hampton, Seabrook, Epping, Raymond, Farmington, Rochester, Somersworth, Rollinsford, Dover, Durham, Newmarket, Newfields, Stratham, Kensington, South Hampton, Brentwood, Kingston, East Kingston, Newton, Fremont, Danville, Hampstead, Plaistow, Atkinson, and Salem. This alternative consists of intake structure on Lake Winnepesaukee with adequate transmission and treatment facilities to supply the 2030 needs of each community. The cost of this alternative is \$6.15/1000 gallons, further breakdown of costs are presented in Table 16.

Major institutional impacts are associated with the development of this alternative due to the large number of communities involved and the transfer of water between drainage basins. State intervention and careful regulation would be necessary if a plan of this magnitude were to be implemented.

The significant environmental and social impacts associated with implementation of this alternative have been outlined in the previous section, Plan Formulation. This alternative does not appear feasible and investigations will not be carried further.

TABLE 16

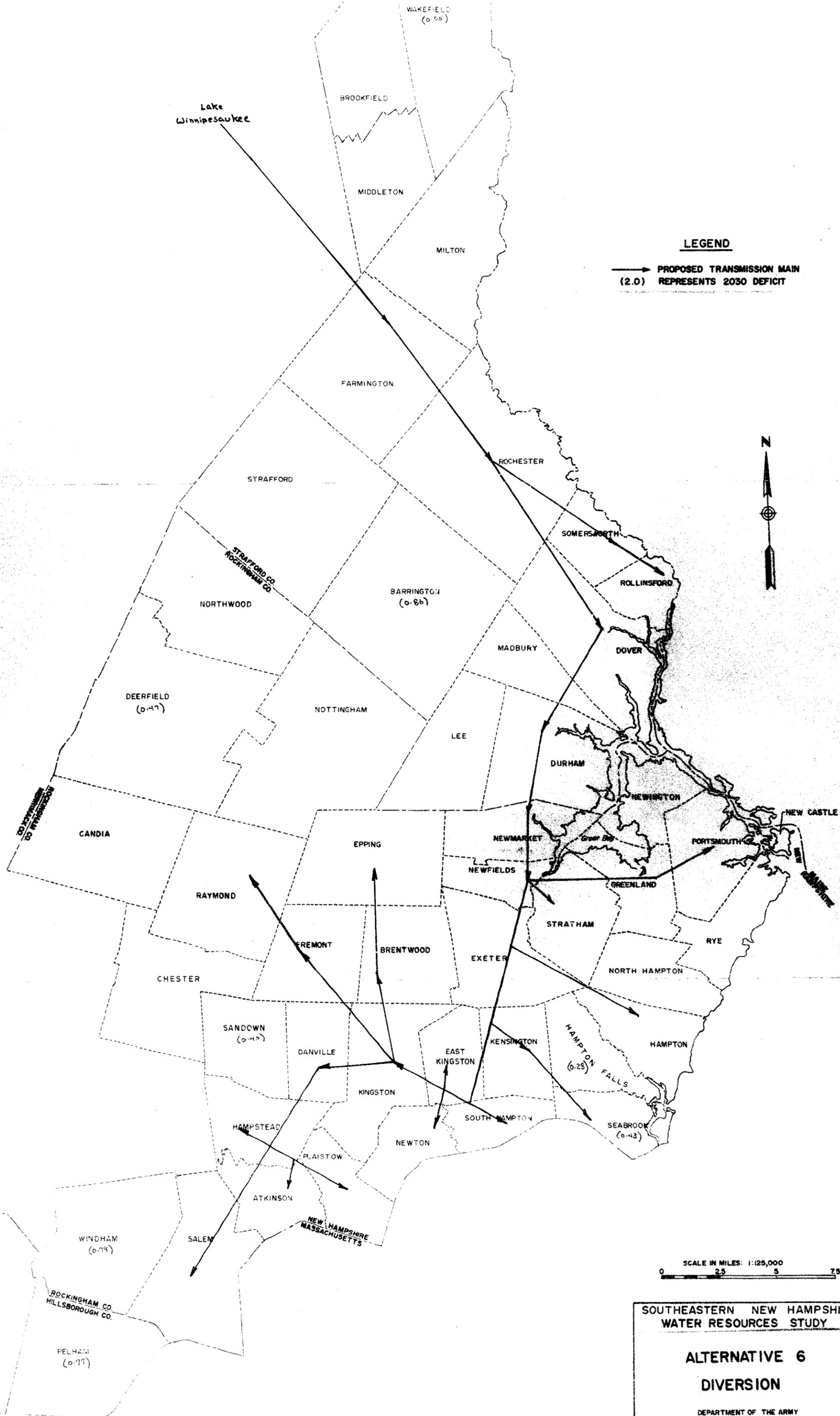
COST SUMMARY

ALTERNATIVE 6: Winnepesaukee Diversion

<u>COMMUNITY</u>	<u>FACILITY</u>	<u>DESCRIPTION</u>	
Total Study Area	Diversion		
	Transmission	Capital Cost	159,888.0
		O&M Cost	23,397.0
	Water Treatment	Capital Cost	35,000.0
		O&M Cost	520.0
		TOTAL CAPITAL COST	194,889.0
		ANNUAL COST	38,262.0
		UNIT COST	6.15

---

NOTE: Capital Costs 1000 \$  
O&M Costs and Annual Costs 1000 \$/year  
Unit Costs \$/1000 gallons  
Annual cost includes O&M cost and amortization of capital cost



WAKEFIELD (0.55)

BROOKFIELD

MIDDLETON

MILTON

FARMINGTON

ROCHESTER

STRAFFORD

SOMERSWORTH

ROLLINSFORD

NORTHWOOD

BARRINGTON (0.86)

MADBURY

DOVER

DEERFIELD (0.47)

NOTTINGHAM

LEE

DURHAM

NEWINGTON

NEW CASTLE

CANDIA

EPPING

NEWMARKET

PORTSMOUTH

RAYMOND

NEWFIELDS

GREENLAND

FREMONT

BRENTWOOD

EXETER

STRATHAM

RYE

CHESTER

NORTH HAMPTON

SANDOWN (0.42)

DANVILLE

EAST KINGSTON

KENSINGTON

HAMPTON FALLS (0.28)

HAMPTON

KINGSTON

SOUTH HAMPTON

SEABROOK (0.43)

HAMPSTEAD

PLAISTOW

NEWTON

ATKINSON

NEW HAMPSHIRE MASSACHUSETTS

WINDHAM (0.19)

SALEM

ROCKINGHAM CO HILLSBOROUGH CO

PELHAM (0.11)

HULLCON



SECTION V

COMPARISON OF PLANS

## V. COMPARISON OF PLANS

Plans developed and discussed earlier in this report are compared against one another in this section. The ability of the plans to meet the study's planning objectives is also evaluated.

A cost summary table for the alternatives and an environmental assessment table are included to summarize some of the major differences among the plans.

### A. Comparison

Each of the 6 plans identified in Section 4 address the water supply needs of the study area but there are distinct differences among the plans as to the degree to which they meet the planning objectives and to the degree of their associated impacts of development. Cost comparisons are shown in Table 17.

Alternatives 1 and 2 were formed to determine the extent development of just local sources would be able to meet projected water supply demands. These two plans are the most publicly acceptable as their development would be the least disruptive to existing conditions. Existing institutional arrangements would not have to be altered for these two plans. Alternative 1, groundwater development, would appear to be the best candidate for the EQ and NED plan at this time. Plans 1 and 2 do not fully meet the planning objectives. These two plans would satisfy the future needs of approximately half of those communities expected to have a 2030 deficit. Thus, plans 1 and 2 might be considered short-term solutions for the study area, but some supplemental sources would ultimately be required.

Alternative 3 addresses a totally regional approach towards future supply. By adopting a regional approach to future needs, the number of sites needed for supply is drastically reduced from that required under alternatives 1 and 2. The total environmental impacts of alternative 3 versus those of alternatives 1 and 2 has not been fully evaluated. The impacts of the individual sites investigated under alternative 3 would be greater due to the larger size of the reservoirs under consideration. The total overall environmental impacts of plan 3, however, are not of a magnitude too great to eliminate this plan from further consideration. A significant change in the existing institutional structure would be required with plan 3. The state would have the responsibility of managing the overall system as existing local companies could not handle these larger systems.

Alternative 4 is a combination of plans 1 and 2. Those communities which had groundwater sources were expected to develop them and the remaining communities would develop available local surface water sources. Impacts for this alternative are similar to those for plans 1 and 2. Public acceptance of this plan would be much greater than plan 3 due to the smaller scale development required and due to the ability of local communities to manage the systems. Although this plan is capable of supplying a greater number of communities than plan 1 or 2 it does not meet all the future demands that alternative 3 does.

TABLE 17

COST SUMMARY

<u>ALTERNATIVE</u>	<u>CAPITAL COST x \$1000</u>	<u>ANNUAL COST \$1000/yr.</u>	<u>TOTAL EQ ANNUAL COST \$1000/yr.</u>
1. Groundwater	12,323.	225.3	1,132.
2. Local S. W.	109,340.	1,139.5	9,198.
3. Regional S. W.*	242,800	9,625.9	27,472.
4. Local S. W. & G. W.	83,783.	1,095.1	7,264.
5. Combination	137,906.	5,938.9	16,089.
6. Winnepesaukee Diversion	194,889.	23,917.0	38,262.

\*The cost of this alternative is high due to the duplicate options available to several communities which are also included in the total cost.

Alternative 5 is a combination of measures presented in Alternatives 1, 2 and 3. Future sources proposed under this plan were chosen after a comparison of economic and environmental impacts identified earlier. Maximum local development was considered more practical with regional sources being developed only when local sources had been exhausted. This alternative would require a change in existing responsibility for water supply management. Some communities considered in the regional proposals presented here could develop local sources at a lower cost than what is presented in this plan but doing this would not meet the planning objectives for the entire study area. Development of future plans will always consider the needs of the entire study area as a whole rather than on a community-by-community basis.

Alternative 6, diversion from Lake Winnepesaukee, will not be considered any further. The cost for development is higher, the economic impacts much greater, institutional impacts would be extensive and public acceptability would be extremely low in comparison to the other five plans.

#### B. Plans Warranting Further Investigation

The five plans which best address the needs of the study area will be further investigated and developed to fully meet the planning objectives of this study. Benefits for water supply will be developed for each plan so that a comparison of plans can be made based on the ability of the plan to meet projected deficits. Development of local sources will continue to be investigated as present planning among communities is along these lines and public preference is strongest for this plan.

#### C. Rationale for Candidate NED Plans

Alternative 1 appears to be the candidate NED plan at this time. This could change when benefits for water supply are determined and "costs" for those communities not supplied under this plan are developed.

#### D. Rationale for Candidate EQ Plans

Alternative 1 would also appear to be the best candidate for the EQ plan. However, none of the plans restore or enhance environmental conditions to the level of the "without condition" - Alternative 1 does have the least environmental impact though.

SECTION VI

STUDY MANAGEMENT

## VI. STUDY MANAGEMENT

This section describes the procedure for completing the study. Planning tasks are presented for the remaining elements required to complete the study.

### A. Methodology

During the final stage emphasis will be on modifying, assessing and evaluating the associated impacts of the proposed alternatives. Assessment and evaluation will be much more specific as well as more closely defined. Results will be a set of implementable plans for future development of water resources in the study area.

### B. Problem Identification

Refinement of the needs and resources will be completed to assure all measures are fully defined. Potential supply from surface and groundwater will be more definitively evaluated. Water supply benefits derived through development of additional sources will be calculated. Cost allocations for development of reservoirs, transmission mains, and treatment plants will have to be made among the communities. This cost allocating will be contingent upon the phased development of additional sources.

### C. Formulation of Alternatives

The five alternative plans will be evaluated in more detail firmly establishing the NED and EQ alternatives. Refinement of the alternatives may be required to make certain they are compatible with the general goals of the public. Final alternatives considered in this stage of the study will be those which best meet the set of planning objectives and are capable of being implemented. Extensive coordination with the public and professional technical evaluation will be used to select these alternatives.

### D. Impact Assessment

Impacts that have previously been identified will now be measured. Significant effects of an alternative are of economic, social and environmental consequences and are likely to have a material bearing on the final decision making process. Magnitude and duration of the impacts will be identified.

### E. Evaluation

This task weighs both total beneficial and adverse contributions of each plan. Consequences, both beneficial and adverse, are determined by comparing the alternative to the "without project" condition. Relative contributions of the alternative plans are then ranked and traded off based on professional analysis as well as preceptions of the public. At the conclusion of this phase of the planning process, evaluation results provide the basis for selecting the most desirable plan and, if appropriate, recommending its implementation.

#### F. Public Involvement

The public involvement program during this stage will be used to evaluate the array of alternative water resource plans in order to develop a selected plan which will be responsive to the planning objectives of the study and the problems and concerns of the region.

This program will also be utilized to determine the social acceptability of a water conservation program. Once the effectiveness of a conservation program can be determined the projected water demands for the study area can be adjusted accordingly.

Public involvement is the key mechanism to insuring that study direction and study results are continuously focused on the needs particular to the region. A series of public workshops will be held to present the preliminary set of alternatives developed to date. Public preference to the plans will be an important aspect in the evaluation.

#### G. Study Schedule and Costs

After submission of this document and completion of the checkpoint conference work will be initiated on refinement of the alternative plans and their associated impacts. The NED and EQ plans will have to be finalized. Milestones which have been completed and the schedule of remaining ones is shown on Table 18. Current study costs and appropriation history are shown on Table 19.

TABLE 18

STUDY SCHEDULE MILESTONES

<u>MILESTONE NUMBER</u>		<u>SCHEDULED DATES</u>	<u>COMPLETION DATES</u>
01	Study Initiation		11-77
02	Submit Reconnaissance Report		07-79
03	Submit Stage 2 Documentation	01-81	
04	Checkpoint Conference	01-81	
05	Complete Action on MFR	03-81	
06	Submit Draft Survey Report	11-81	
07	Checkpoint Conference	01-82	
08	Complete Action on MFR	03-82	
09	Coordinate Draft Survey Report and DEIS	04-82	
10	Submission Final Draft Survey Report and RDEIS	08-82	
11	Submission Final Report to BERH	09-82	

TABLE 19

CURRENT STUDY COST AND APPROPRIATION HISTORY

Current Study Costs

Plan Formulation and Evaluation

Need Identification	\$10,000
Formulation of Alternatives	35,000
Impact Assessment	80,000
Evaluation	50,000
Public Involvement	<u>16,000</u>

TOTAL \$191,000

Appropriation History

FY 1978	\$ 50,000
FY 1979	\$235,000 (Additional transfer of \$105,000)
FY 1980	\$128,000
FY 1981	\$191,000
FY 1982	\$150,000
Balance	<u>\$ 91,000</u>

TOTAL \$845,000

SECTION VII

CONCLUSIONS

## VII. CONCLUSIONS

### A. Study Direction

Local interests have long felt that there is a serious water supply problem in Southeastern New Hampshire. Their representative in Congress submitted a resolution which authorizes this study as stated on page 1. This resolution was submitted so that Federal assistance could be provided to examine the chronic water supply problem and other water resource problems of the area and develop and evaluate alternative solutions to the problem. Our demographic studies and water demand projections have confirmed that water needs are fast outstripping available supply. A dichotomy of thinking has been evident with regard to solving the problem. Some planners believe that a regional system which would include new reservoir(s) is the best plan. Others feel that the best solution is to continue to develop groundwater sources. This latter group notes that groundwater sources have been successful in the past, providing an inexpensive, high quality water in sufficient quantity to meet needs.

This study has looked at, and will continue to look at both approaches and to demonstrate the trade-offs of each. A clean-cut comparison between surface and subsurface water as a supply source has not been possible in the past because sufficient information on subsurface sources was not available. An intensive data collection program in the earlier phases of this study has provided a base of knowledge to work from. Information on aquifer location, soil type, and water quality that is available was gathered, organized and analyzed. Gaps in the data were filled with new seismic explorations and in some cases drill holes.

Data to evaluate aquifers were not readily available; however, groundwater data were developed to a point where yields could be estimated with a high level of confidence. This is important when planning for the future. In the past planners could have confidence in surface water yields because of good historical stream gage records. No comparable aquifer data were available and as a result regional planners have foregone the uncertainties of groundwater and developed plans that emphasized surface water sources.

Now potential groundwater and surface water sources are able to be treated on an equal basis. They can be judged solely on cost, quality and quantity of the various sources. It is no longer necessary to shy away from groundwater sources because of the uncertainties of yield.

Alternative plans of meeting projected water supply demands have been developed. These alternatives include all sources singly and in combination: groundwater, reservoirs, diversions. The next stage of the study will include a public presentation of the alternatives so that they can be modified or supplemented to meet the needs of the public. An extensive evaluation of the final array of alternatives will follow. This evaluation will include cost, water quality, social and environmental impacts and public acceptance as criteria.

The final product will be in the form of alternative plans, together with the trade-offs of each plan, presented in a manner that will allow the decision maker to make rational decisions.

## B. Local Involvement

Final decisions on future water supply are a local matter, whatever plan is finally selected will be implemented locally with non-Federal money. The purpose of this study is simply to develop and present the information needed to make a wise decision at the local level.

With this in mind, it becomes all the more clear why public involvement during the study is important. Plans must be formulated so that they are consistent with state and municipal statutes, policy, and preferences. To conform the Corps' planner must have the knowledge which is gained by contacts with the public at all levels.

Local support has been excellent during the earlier phases and we expect the high level of interest to continue throughout the remainder of the study. As the various facets of work are completed they will be reviewed at the local level. The alternative plans carried in this document will be presented at public meetings to determine their acceptability. The meetings will also give the public a chance to tell us if they know of other alternatives that they would like to have evaluated. The public involvement program will, of course, extend far beyond public meetings. We will be looking to the State and Regional Planning Agencies to accomplish specific tasks. We will continue to hold informal meetings with special interest groups both in the public and the private sector, and to make our draft reports available for public review.

## C. Policy and Other Issues to Resolve

Institutional arrangements among the State, community, regional planning agencies, and private water companies will have to be resolved prior to implementation of any alternatives. A legislative committee is currently working towards development of a State water policy. The intent of this policy will be to set the direction of future water resource planning in the State. Institutional arrangements proposed in this study will have to be compatible with the State water policy once it is adopted.

A clause in the proposed 1981 Water Resources Development Act, now before Congress, would greatly expand the government's interest in water supply - perhaps to the extent of project implementation by the government. There is no assurance that this change will ever come about so, for purposes of this study, we are basing our work plan on existing authorities which allow the Corps to develop water supply plans for local implementation.

SECTION VIII

RECOMMENDATIONS

#### VIII. RECOMMENDATIONS

It is recommended that study efforts proceed to completion of the study. There is and has been an intense interest in the State of New Hampshire for development of water supply alternatives. Work completed to date has already been utilized by others in water resource planning for the State. Completion of this study will provide the State with an effective plan for future water resource development.

APPENDICES

## APPENDIX A

### METHODOLOGY FOR AREAWIDE PLANNING STUDIES (MAPS)

The MAPS computer program is a tool developed by the Environmental Laboratory of the U.S. Army Engineer Waterways Experimental Station to assist Corps personnel, primarily engineers, in screening alternative facility plans. While it has applications in other areas, it has primarily been used in water supply studies. The MAPS program has been used to perform preliminary design and cost estimates for screening water supply alternatives in the Southeastern New Hampshire Water Resources Study. These cost estimates are for the purpose of comparing alternatives and are not to be used by utilities or municipalities as engineering estimates of individual projects.

The cost estimating methods used in MAPS are designed to produce reasonably accurate estimates for a large number of alternatives, given the limited amount of data usually available in a planning study. The accuracy of the estimates depends on how closely the facility under consideration resembles the facilities or components used in developing the cost estimating procedures. The methodologies and cost data used by the program have been reviewed and compared to actual bid prices and construction cost estimates of projects in the area and, therefore, have been found to be sufficiently accurate for stage 2 planning studies.

The main design and cost routines used to evaluate the alternatives in this study are transmission mains, pump stations, treatment plants, well-fields and dams. A description of the input and analysis of the cost data for each routine is presented in the following section.

#### Transmission Mains

The design and cost of transmission mains are based on the data shown in Table A-1. The MAPS program calculates the diameter, required head and all associated costs from this data. Costs determined by the program include construction, overhead and operation and maintenance.

TABLE A-1

#### Transmission Main Input

<u>Description</u>	<u>Data or Source of Data</u>
Length	USGS Quad, Scale 1:62,500
Initial Elevation	USGS Quad, Scale 1:62,500
Final Elevation	USGS Quad, Scale 1:62,500
Peak Elevation	USGS Quad, Scale 1:62,500
Final Pressure	50 ft.
Depth of Cover	5 ft.
Rock Excavation	20%
Ductile Iron Pipe	For Diameters 4" to 48"
Reinforced Concrete Pipe	For Diameters 54" to 120"
Bends or Elbows	12 per mile
Gate Valves	3 per mile
Dry Soil Conditions	Assumed throughout
100% Open Country	Assumed throughout
Design Flows	Run with 2030 maximum and average day deficits.

## Water Treatment Plants

The water treatment plant design module in MAPS can calculate planning level construction, overhead, operation and maintenance, and average annual costs of water treatment plants based on the unit processes used and the design and operation specifications for these processes. However, MAPS water treatment plant costs were found to be extremely low and therefore were not used to development treatment costs for this study. Treatment costs were obtained from cost curves developed for the study area.

## Pump Stations

The design and cost of pump stations are based on the data obtained from the transmission main routine. The MAPS program, through a pipeline design module, will cost and design several combinations of pipe diameter and pump stations for a length of pipe. The user is then able to select the optimal diameter and section size from the data. Costs associated with pump stations include; construction, overhead and operation and maintenance.

## Dams

The MAPS dam module calculates the cost for a dam and reservoir given a description of the dam and reservoir, which includes the existing ground elevations at the dam site. A typical dam section is shown in Plate A-1, other data used in the cost and design routine is shown in Table A-2. Costs determined by the program include; construction, overhead, and operation and maintenance.

TABLE A-2  
Dam Module Input

<u>Description</u>	<u>Data or Source of Data</u>
Embankment description	(See Plate A-1)
Drainage area	S.C.S. Data
Reservoir storage	S.C.S. Data
Reservoir surface area	S.C.S. Data
Spillway design flow	Max. Probable flood curves
Outlet design flow	50 cfs/sq. mi.
Relocations	S.C.S. Data

The cost analysis used to evaluate each alternative is based on a 50 year study period beginning in 1980 and extending to 2030. An Engineering News Record Index of 3300 and an interest rate of 7.125% is used throughout the study.

Capital costs are broken down into overhead and construction costs. Overhead costs include engineering, interest during construction, legal, fiscal and administrative costs. Construction costs include materials, equipment, structure and other construction items specific to the facility being built. Costs for dikes are not included in the total construction costs.

Wellfields

The MAPS wellfield module determines the costs for one or more wells installed in a wellfield. Wells within the wellfield are assumed to have similar properties such as: each well (a) delivers roughly the same flow, (b) is drilled to approximately the same depth, (c) draws from the same aquifer, (d) has the same design life, and (e) is located in the same geographical area. Table A-3 lists the data used to design and cost wellfields for this study. Costs determined by the program include; construction, overhead and operation and maintenance.

TABLE A-3  
Wellfield Input

<u>Description</u>	<u>Data</u>
Design Flows	2030 maximum and average day deficits
Number of Wells	based on 0.5 mgd/well
Drilled Depth	*From data compiled for study area
Groundwater Depth	*From data compiled for study area
Drawdown Rate	*From data compiled for study area
Radius	*From data compiled for study area

\*Groundwater Assessment for Southeastern New Hampshire, September 1980

TYPICAL DAM SECTION

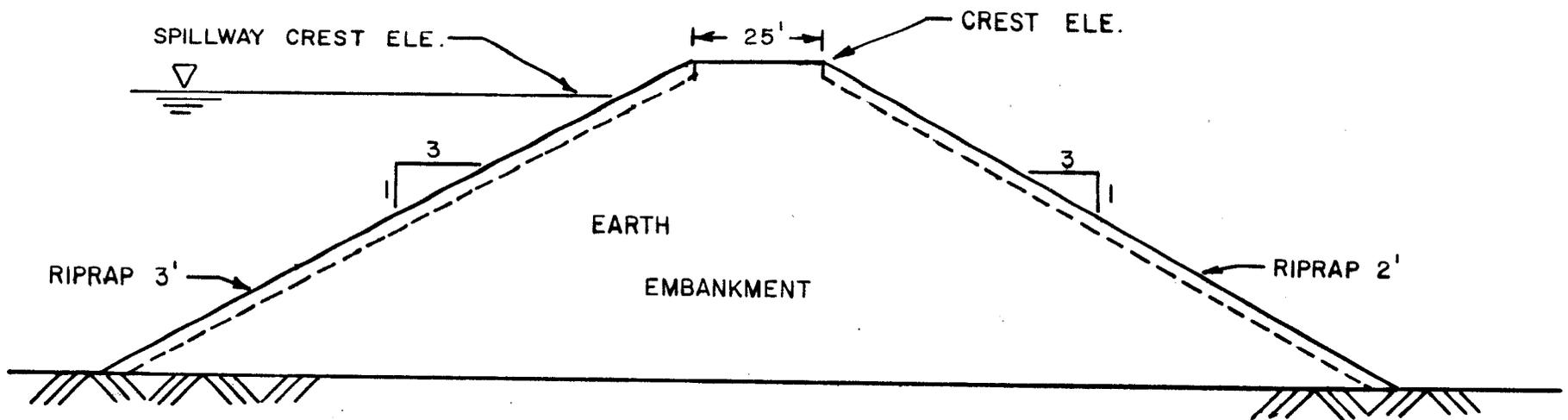


PLATE A-1

## APPENDIX B

### STUDY BIBLIOGRAPHY

In May 1979, the Corps of Engineers completed a reconnaissance report for Southeastern New Hampshire which identified various work items necessary to formulate plans for development of the area's water resources. Two major work items identified at that time were the development of demographic projections and the assessment of groundwater resources. These items have since been completed and are discussed below.

Demographic/economic projections for the Southeastern New Hampshire region were prepared by Abt Associates Inc., under contract by the Corps of Engineers. These projections have been used to determine the future water needs of the area, as well as serving as a baseline against which the impacts of proposed future water resource development projects may be evaluated.

From a starting point of July 1, 1975, projections of future demographic and economic conditions have been made at five-year intervals through the year 2030. Demographic variables include such items as population, births, deaths, migration, household, labor force, and so on, while economic projections include employment, earnings, and personal income. The demographic projections are presented by sex and five-year age group (0-4 years of age, 5-9, 10-14, ..., 80-84, and 85 years of age or older), while the economic projections are presented by major industry groups (essentially one-digit sectors).

The projection model consists of the following six components: (1) demographic model; (2) economic model; (3) labor market model; (4) migration model; (5) household model; and (6) community allocation model. A "top-down" approach is used in generating the projections: first, county-level projections are prepared, using the first five elements listed above; then, those totals are disaggregated to individual communities, utilizing the sixth submodel; and, finally, study area totals are computed as the sums of the community projections.

The first step in the projection process involves establishing baseline conditions, updating Census data from April 1, 1970 to corresponding values as of July 1, 1975, using available intercensal estimates and other information. The second step in the process considers the estimation of various model parameters, calibrating the models to reflect existing local conditions and recent trends. The third step requires the modification of the various national projections which will serve as exogenous variables, driving the county projections (e.g., fertility rates, survival rates, household headship rates, labor force participation rates, and projections of employment and earnings.)

Following these preliminary steps, the model proceeds through sequential application of the six submodels for each county and each five-year projection period. Each submodel draws upon input data which have been organized according to geographic detail: national data, state data, county data, and community data. The submodels also utilize relevant model parameters and national projections, which have been previously calculated. Each submodel then generates the final projections and intermediate results to be used by the other submodels.

Finally, the results of the computer projection model are examined and analyzed, considering the range and reasonableness of the final projections. Where appropriate, projection techniques and/or model parameters have been modified to insure reasonable results.

Assessment of groundwater resources for the southeastern New Hampshire region was conducted in two phases. Phase I, entitled "Phase One Groundwater Survey for Southeastern New Hampshire" September 1978, undertaken by the firm of Hayden, Harding and Buchanan, Inc., was conducted on 81 aquifers delineated by the Corps of Engineers. The study consisted of field investigations to evaluate the aquifer potential and verify soil deposits. At the conclusion of this phase, 53 sites were judged to warrant further investigation and modifications were made to the previous aquifer delineations.

The Phase II study, entitled "Groundwater Assessment for Southeastern New Hampshire" September 1980, performed by Anderson-Nichols and Co., Inc., endeavors to determine the quantity and quality of groundwater in those 53 aquifers identified in the Phase I study as requiring further investigation as well as to three aquifers which were added during the study at the request of State of New Hampshire officials. However, during the course of this Phase II study some of the aquifers were eliminated and others were added resulting in 61 potential aquifers being evaluated.

The principal study tasks encompassed reviewing initial Corps of Engineers' reports, collecting additional data to allow sufficient delineation of the 61 potential aquifer sites, and making a field reconnaissance of the 20 sites not visited by Corps geotechnical personnel. These tasks led to the development of a suitable methodology for the quantitative evaluation of the potential safe sustained yield of the aquifer sites.

This study provided the basis for evaluating groundwater as a municipal water supply source for the study area.